TECHNOLOGY DEPT

TECHNOLOGY REVIEW

December 1957

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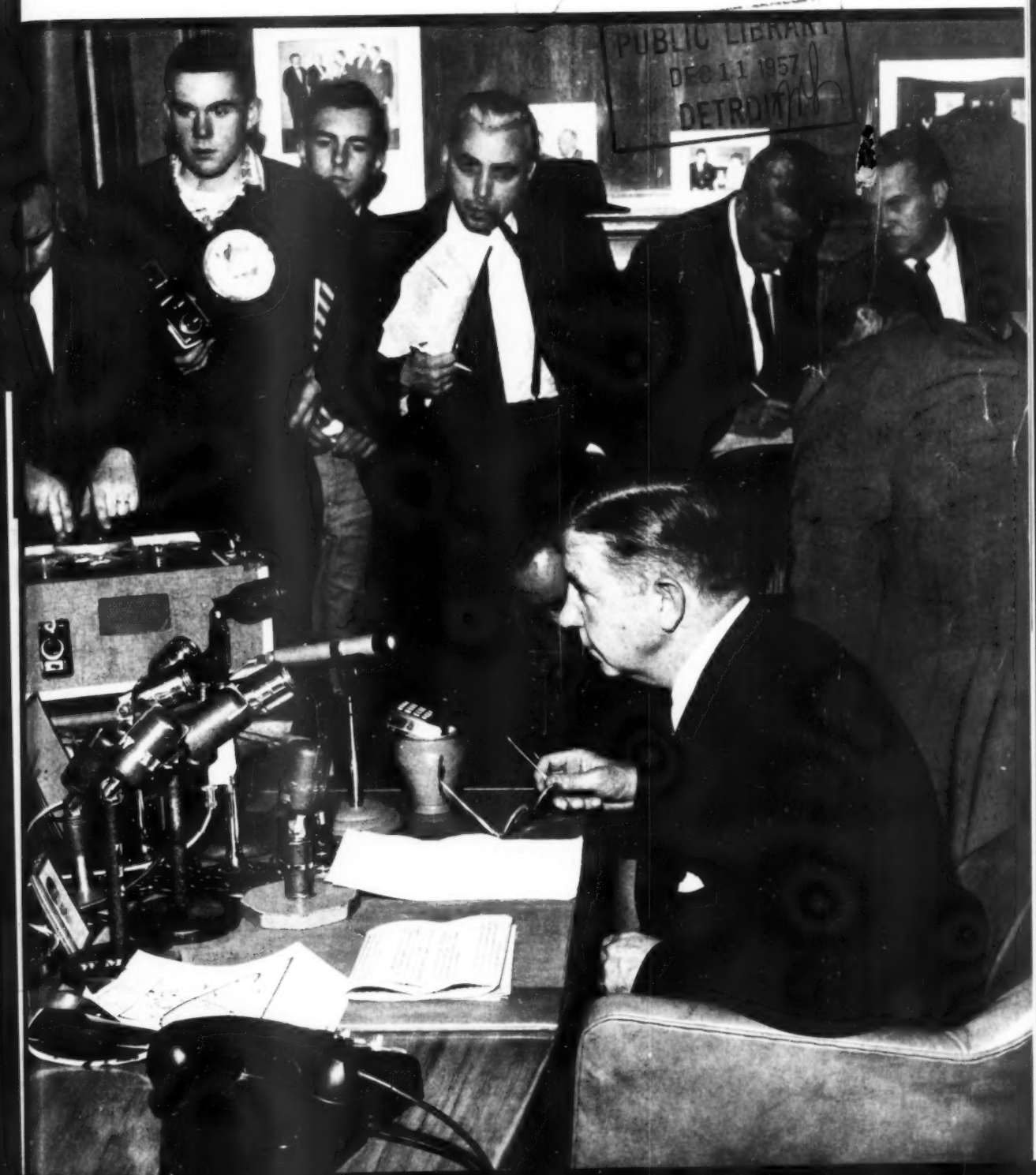

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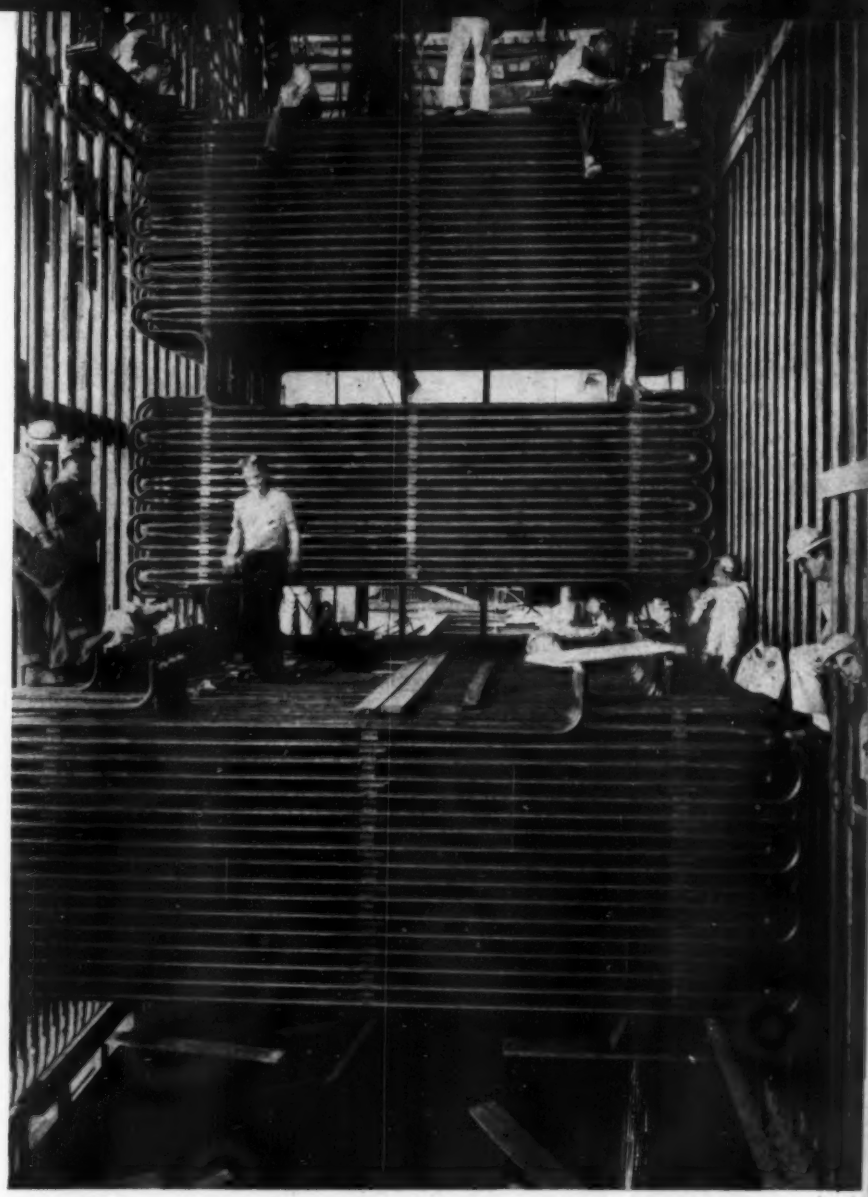

In the good old days, it was a simple matter to boil water and make steam. The large utility boilers of half a century ago would fit in many a modern living room . . . top steam pressures were about 200 pounds per square inch . . . and temperatures not much above the boiling point in a tea kettle.

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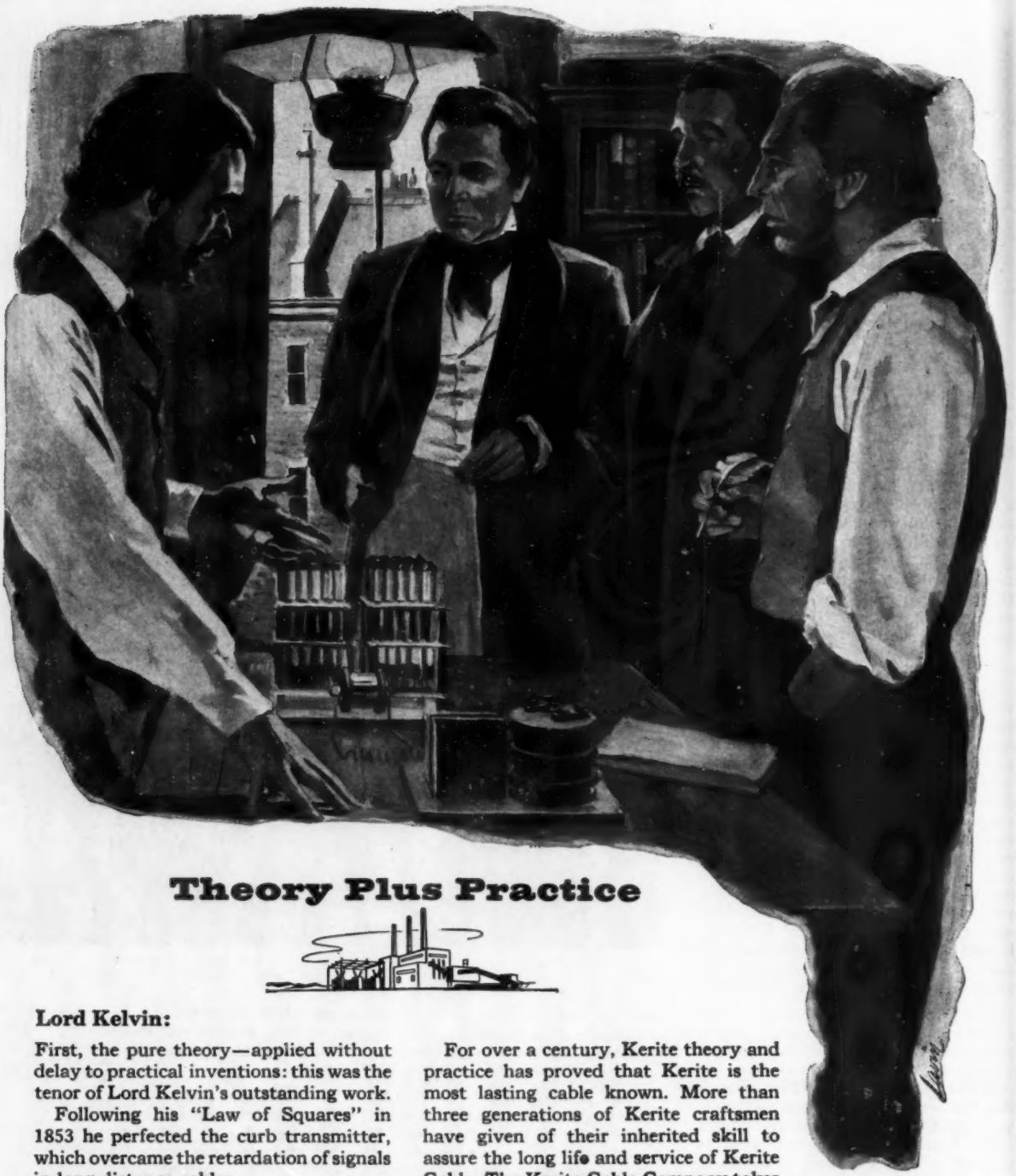

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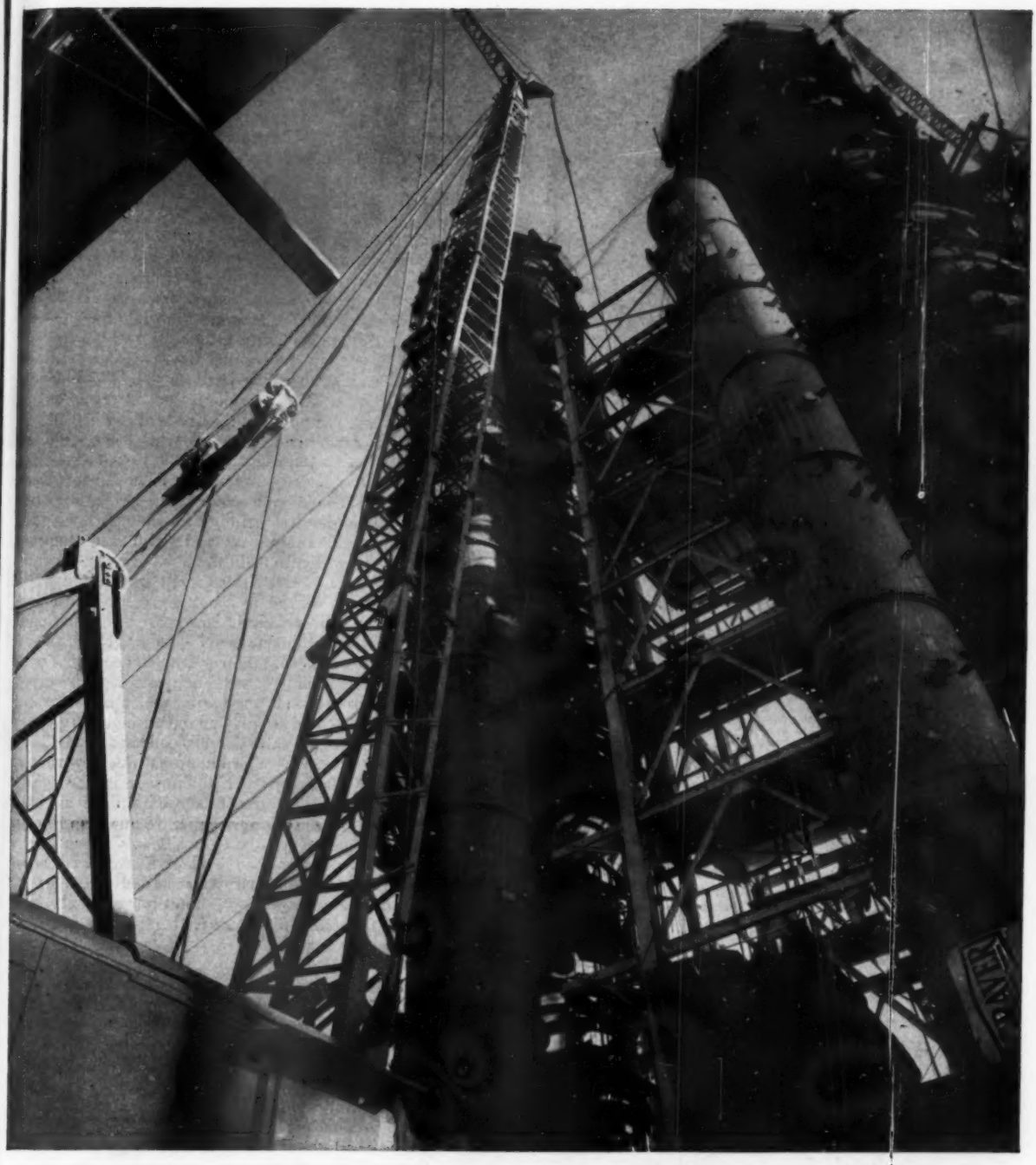

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THE TABULAR VIEW

M.I.T.'s Founder. — Last spring, the College of William and Mary held impressive ceremonies in celebration of the 75th anniversary of the death of an illustrious alumnus. Taking part in these ceremonies, at which he received an honorary D.Sc. degree, was JAMES R. KILLIAN, JR., '26, the 10th President of the school founded by William Barton Rogers in 1861. President Killian's able dissertation on the life of the founder of M.I.T. appears on page 105 of this issue. It sheds additional light on the life of the William and Mary alumnus whose long-cherished hope to found a new type of school (in which pure and applied science were fused and their cultural and utilitarian values used to the fullest) found fruition in Boston. That President Rogers' concepts on education are fully adapted to the needs of our Twentieth Century society are evident to all who have followed President Killian's administration of "Boston Tech." For nearly a third of a century, the pages of The Review have reflected Dr. Killian's impressive work as author, editor, educator, and administrator. His biography needs no recital here, although new and significant chapters will certainly be added to it. In the light of recent events, prophetic indeed are Dr. Killian's remarks (page 128) that, "If we are to survive as a nation, science most certainly will play an increasingly large part in our national life." With his appointment on November 7, as Special Assistant to President Eisenhower for Science and Technology, Dr. Killian embarks on a new and highly significant mission for national service in which science and technology are destined "to play an increasingly large part in our national life." Naturally his colleagues, in Cambridge as well as elsewhere, are happy at this new recognition of Dr. Killian's unusual abilities. It is gratifying, too, to learn that – without exception so far as The Review knows – the many newspaper accounts and radio and television commentaries on Dr. Killian's appointment have hailed his selection by President Eisenhower as an ideal man for a difficult post. As recorded on pages 96 and 97 of this issue, Dr. Killian is now on leave of absence from M.I.T. The Institute's loss is the nation's gain.

Man's Achievement. — No stranger to Review readers is JAMES A. TOBEY, '15, whose article in this issue (page 109) traces the antiquity of disease throughout recorded history and even back to the time when huge, prehistoric reptiles roamed at will in the primeval ooze. Dr. Tobey takes comfort in the knowledge that, in the short span of about a century, man has found ways of using his mind to overcome most of the maladies from which he has suffered throughout the ages. Certainly there is hope that other maladies of man can be overcome likewise by developing and properly directing first-rate minds. After having attended the Roxbury Latin School, Dr. Tobey received the S.B. degree from M.I.T. in 1916, the LL.B. degree from Washington Law School in 1922, an M.S. degree from the American University in 1923, and the Dr.P.H. degree from M.I.T. in 1927. Dr. Tobey's professional life has been spent in advancing public health and in improving state and national laws affecting it. Dr. Tobey has lectured at such universities as Yale, Harvard, Columbia, and M.I.T., has served the Army's Medical Service in the role of Colonel, and is a lucid and prolific writer on topics dealing with public health. Dr. Tobey

(*Concluded on page 92*)

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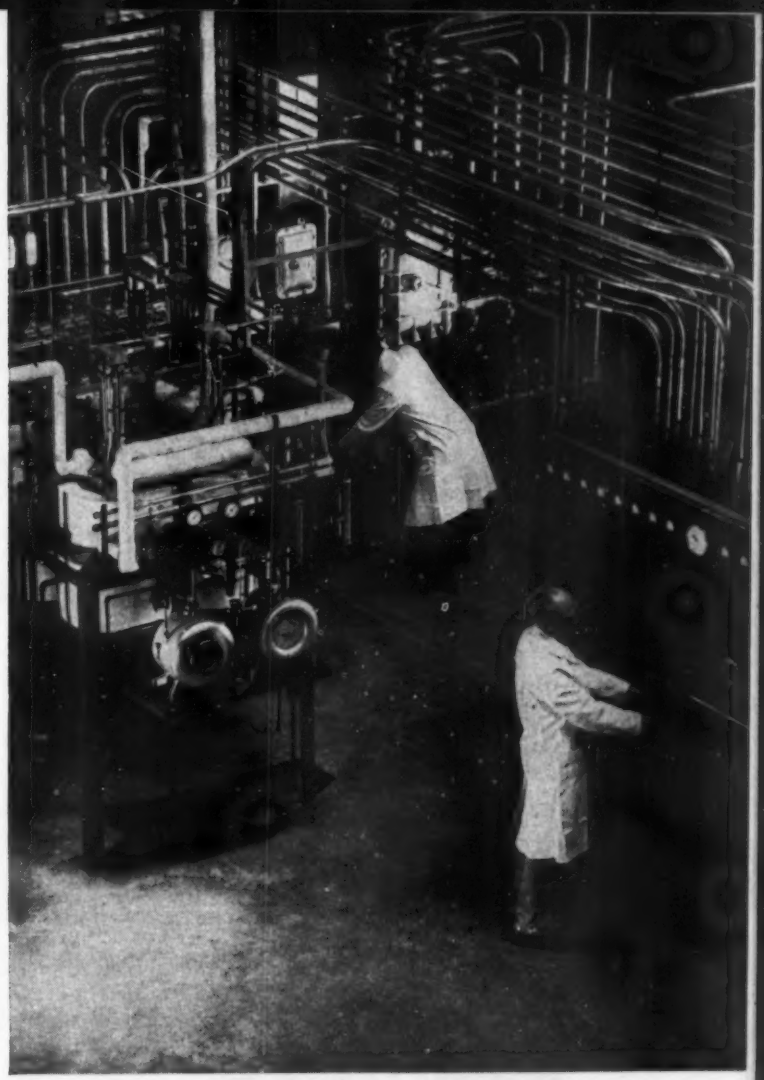
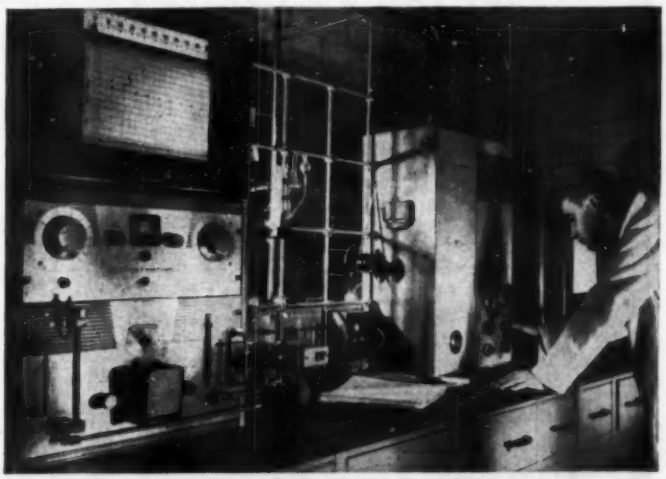


MOST PILOT UNITS at The Center are put together from standard "building blocks." Skid-mounted charging units such as the one at left hold tanks, heaters and pumps for transfer and metering. Process equipment, here shown in background center, can be widely varied. At right is electrical control cabinet. All switches, relays and controls not housed in explosion-proof boxes are enclosed in cabinets like this one, pressurized with outside air to exclude process vapors.



ANALYSIS OF MATERIALS processed and produced in pilot operations at The Center is an important part of the work carried out by Lummus engineers. Here a laboratory technician determines the composition of a multiple-component gas, using a gas chromatography technique.

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THE TABULAR VIEW

(*Concluded from page 90*)

is author of *Public Health Law*. He also has been associate editor of the *American Journal of Public Health*, has written about 20 pamphlets and more than 100 articles. Connecticut and Florida both claim him as resident.

Society's Problem. — After advancing the argument that it is society at large who shouts loudest to benefit from technology, LAWRENCE R. HAFSTAD deplores the fact (page 111) that the mass of our population remains ignorant of the foundations on which their technological society is based. Dr. Hafstad holds that a major and urgent problem of our society is to revise and stiffen our educational system, for "progress cannot be made without struggle, nor freedom enjoyed without personal responsibility." He emphasizes, especially, the need for mature, responsible citizens to have a good background in those subjects — primarily mathematics, physics, and chemistry — on which a technological society depends. Dr. Hafstad received the B.S. degree in electrical engineering from the University of Minnesota in 1926, and the Ph.D. degree in physics from the Johns Hopkins University in 1933. From 1928 to 1946 Dr. Hafstad was on the staff of the Carnegie Institution of Washington. During World War II he was assigned to the staff of the Applied Physics Laboratory of Johns Hopkins at Silver Spring, Md. In 1947 he became executive secretary of the Research and Development Board, Office of the Secretary of Defense. In addition, he served as professor of applied physics at Johns Hopkins from 1947 to 1954, and was director of the Johns Hopkins Institute for Co-operative Research from 1947 to 1949. Between 1949 and 1955 he was first director of the Reactor Development Division, Atomic Energy Commission, and from 1949 to 1951 carried a Presidential appointment as chairman of the Interdepartmental Committee on Scientific Research and Development. In January, 1955, he became director of the Atomic Energy Division of the Chase Manhattan Bank, and later that year became vice-president of General Motors Corporation, in charge of the Research Staff. Dr. Hafstad's article was delivered before a meeting of Sigma Xi, and is reprinted from *American Scientist*, Volume 45, Number 2, March, 1957.

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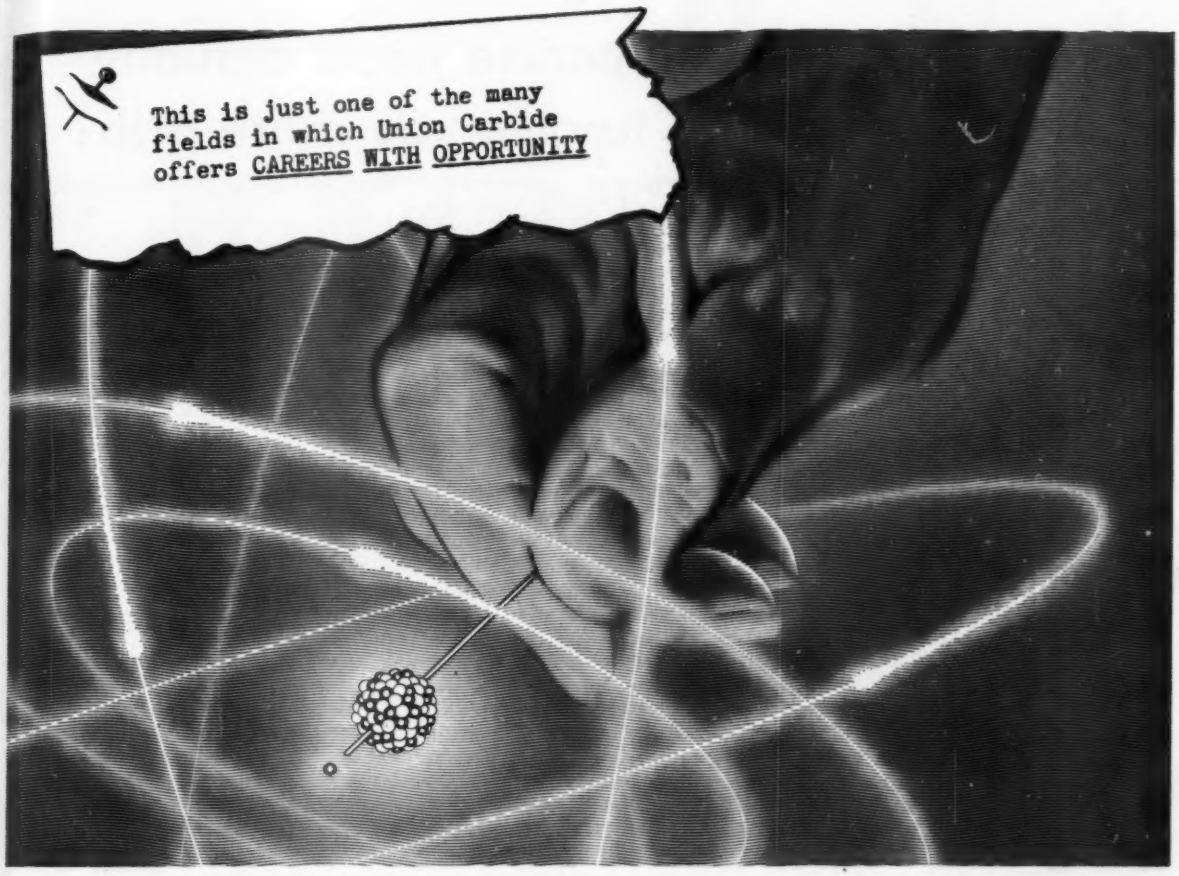

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THE TECHNOLOGY REVIEW

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Relating to the Massachusetts Institute of Technology

M.I.T. Photo

"Standing room only" is available to hundreds as doors to Kresge Auditorium are closed half an hour before delivery of the first Karl Taylor Compton Lecture by Niels Bohr.

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Fabian Bachrach

◄ JAMES R. KILLIAN, JR., '26

Named by President Eisenhower as Special Assistant to the President for Science and Technology in a nationwide radio and television address on November 7, President Killian speedily moved to Washington to take up his new duties of national service.

The administration of Dr. Killian, as 10th President of the Massachusetts Institute of Technology, has been marked by great expansion of M.I.T. and its educational facilities and services, increased responsibilities for defense research, and greater emphasis on the humanities and social sciences in the education of scientists and engineers.

Dr. Killian has long served the national government in a number of important advisory capacities. He is a member of the Science Advisory Committee, the Office of Defense Mobilization, and of the Board of Trustees of the Institute for Defense Analysis, Inc.—an organization set up by M.I.T. and four other universities for applying scientific methods and analysis to military problems. In 1955 he was appointed by President Eisenhower to be chairman of the Board of Consultants on Foreign Intelligence Activities, and for a five-year period he served as chairman of the Science Advisory Panel for the Department of the Army. He served as chairman of the Technological Capabilities Panel under direct appointment of President Eisenhower from 1953 to 1955. In 1951-1952, Dr. Killian was chairman of the Air University's Board of Visitors, and a member of the Board of Visitors of the United States Naval Academy from 1953 to 1955. He was also a member of the Committee for the White House Conference on Education in 1954 and 1956.

JULIUS A. STRATTON, '23 ►

Since 1949, when he was appointed Provost, Dr. Stratton has been a principal administrative officer of M.I.T. He became Vice-president and a member of the M.I.T. Corporation in 1951, and was appointed Chancellor in 1956, becoming a member of the Corporation's Executive Committee at the same time. As Chancellor and Vice-president, Dr. Stratton was already in charge of the Institute's academic program and served as general executive officer for all Institute affairs when he was named, by President Killian, to the post of Acting President of M.I.T. while Dr. Killian is on leave for his important Washington assignment.

After studying at the University of Washington, M.I.T., University of Grenoble, University of Toulouse, and the Eidgenossische Technische Hochschule of Zurich, Dr. Stratton returned to the Institute, where he served as assistant professor in the Department of Electrical Engineering and later as a full professor in the Department of Physics. He, too, has had a broad background of scientific and administrative service to the nation. He was one of the first members of the staff of the Radiation Laboratory, established by M.I.T. in the summer of 1940, to develop radar systems. In 1942 he became Expert Consultant in the Office of the Secretary of War. During this period he organized a series of technical advisory committees to the Air Force on programs involving use of radar techniques. After World War II, he established the Research Laboratory of Electronics at M.I.T. and served as its first director until 1949 when he was appointed to the newly created post of Provost.

Fabian Bachrach

The Technology Review

VOL. 60, NO. 2 DECEMBER, 1957

The Trend of Affairs

Killian Named Special Assistant for Science and Technology

■ In his radio and television address before the nation on November 7, President Eisenhower announced that James R. Killian, Jr., '26, had been named Special Assistant to the President for Science and Technology. The announcement came during an address intended to allay public concern regarding the relative progress of the United States and the U.S.S.R. with respect to technical achievements for military purposes.

Response to President Eisenhower's selection of M.I.T.'s President to serve in the newly created post was unanimously favorable. Dr. Killian has had long experience in service on various important governmental agencies relating to national defense and education. The esteem with which President Killian is regarded was stated by President Eisenhower as follows: "He is a man who enjoys my confidence and the confidence of his colleagues in the scientific and engineering world, and in the Government." Dr. Killian's position as President of a world-renown technological educational institute, together with his unique personal qualifications for the new Washington assignment, has done much to enable President Eisenhower to recapture public confidence that the nation's scientific man power will be effectively utilized for national security.

Service for the nation's welfare is no innovation for the Institute's 10th President. During World War II, Dr. Killian was responsible for M.I.T. administration while the late President Karl T. Compton was frequently on leave of absence to serve national interests on important scientific assignments. Particularly since he became President of M.I.T. in 1949, Dr. Killian has also made important personal contributions to national policy on matters of education and science, as recorded on the opposite page.

Immediately after President Eisenhower's address, Dr. Killian announced, in a press conference, that Julius A. Stratton, '23, Chancellor of M.I.T. since 1956, had been appointed by the Corporation's Executive Committee to assume the duties of M.I.T. President during the period that Dr. Killian will be on leave of absence in Washington. In making this announcement, Dr. Killian said:

> The availability of Chancellor Stratton to assume all the duties of the Institute's presidency during my absence has made it possible for me to accept President Eisenhower's invitation to come to Washington. Dr. Stratton and I have worked in closest rapport and partnership over a long period of time in the administration of the Institute and he is superbly qualified to execute all of the duties and responsibilities of its presidency. He will serve as the Chairman of the Executive Committee of the M.I.T. Corporation and perform all of the other functions of Chief Executive during my period of leave.

Of his own appointment, Dr. Killian remarked:

> In behalf of the President I shall move as rapidly as possible to marshal the best scientific and engineering judgment and creative talent in the United States and to make it available to the President for the formulation of national policy which involves science and technology. The President has provided a means to integrate American science in every proper way with national policy-making, and I shall seek to facilitate this by every means at my disposal. A very strong scientific advisory group is an essential part of the plan, and the recruiting of this group will proceed with the utmost dispatch.
>
> The President has clearly stated his strong convictions about the importance of science and scientific education to our national life and security and his desire that everything possible be done to encourage scientific research and education and to strengthen any deficiencies.

Dr. Killian and Dr. Stratton are both Technology Alumni and have served the Institute – except for leaves of absence in connection with national security – since their graduation from M.I.T. Both are superbly qualified for their current pressing assignments, and both have the wholehearted respect and enthusiastic support of their colleagues in science and education. Alumni, Faculty, staff, and students alike take pride in their accomplishments as President Eisenhower looks to M.I.T. for new leadership in science and technology. The Review extends to both of them every good wish in their new undertakings.

M.I.T. Photo

Niels Bohr . . . on steps of Rogers Building at M.I.T. on October 22 on his way to Washington where he received the Atoms for Peace Award and medal shown at lower right.

Bohr at M.I.T.

■ Niels Bohr, one of the world's greatest living scientists, gave six lectures at M.I.T. during November. The Danish physicist, who came to the United States late in October, received the $75,000 Atoms for Peace Award in Washington on October 24, and spent the remainder of the month and most of November in Cambridge. He was the first guest of M.I.T. to give the Karl Taylor Compton Lectures, established in memory of the former president of the Institute.

Presentation of the first $75,000 Atoms for Peace Award was made to Professor Bohr, 71-year old Danish scientist and dean of nuclear physics, during a special convocation at the National Academy of Sciences in Washington on October 24. President Eisenhower headed the distinguished body of government and United Nations officials, scientists, diplomats, and industrial leaders invited to attend the convocation.

The award presented to Professor Bohr is the first of 10 to be granted to those persons anywhere in the world who have made the greatest contributions to the peaceful uses of atomic energy. The Atoms for Peace Awards were created in 1955 as a memorial to Henry Ford and Edsel Ford. Funds are provided by the Ford Motor Company Fund which has authorized $1,000,000 for the purpose.

The award to Professor Bohr was presented by President Killian who is chairman of the Board of Trustees of Atoms for Peace Awards. Professor Bohr was also presented with a sculptured gold medal, which was executed by Sidney B. Waugh, '27.

A brilliant student as a youth, Professor Bohr opened up a whole new era in atomic physics when, at the age of 28, he presented a basic theoretical work on the structure of the atom and contributed materially to the study of quantum physics.

The key address at the convocation in Washington was delivered by Arthur H. Compton, younger brother of the late President Compton in whose memory the Karl Taylor Compton Lectures were given by the Danish scientist.

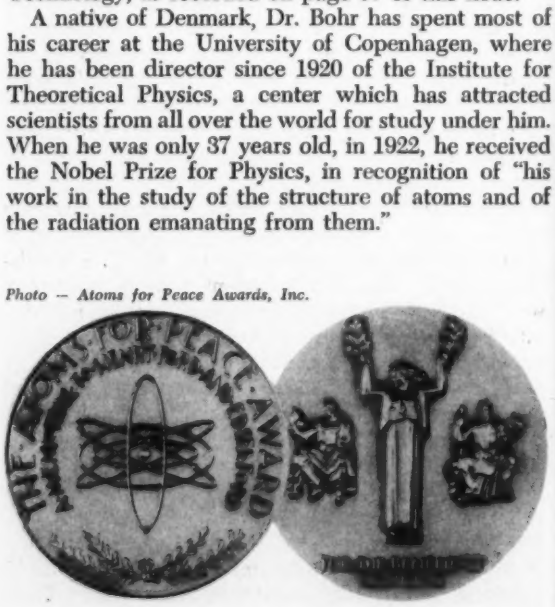
In his lectures at M.I.T., Dr. Bohr gave an elementary account of the development of quantum physics, in which he had a leading part and of which many of today's scientific achievements are the product. He also discussed philosophical implications of modern scientific thought. Seminars in which M.I.T. professors and students participated with him were also held during his stay in Cambridge.

The initial lecture on November 5, in which Professor Bohr reviewed the development of man's thinking about the universe from ancient times to the present, drew a tremendously large and unexpected crowd. Well before the start of the lecture at 8:00 P.M., Kresge Auditorium was filled to capacity, with an audience overflow in the aisles and on the stage. The Kresge lobby provided some accommodation for the many who came to hear Professor Bohr, as may be glimpsed from the print on page 95. Probably more than 1,000 people were turned away, among them numerous extremely disappointed Faculty members. Even Professor Bohr and J. A. Stratton, '23, M.I.T. Chancellor (who presided) had difficulty in entering Kresge!

Professor Bohr's second lecture on November 7 coincided on the hour with President Eisenhower's address to the nation. The large audience who listened to Professor Bohr that evening also heard, at the end of his lecture, a transcription recording of President Eisenhower's speech, in which he announced the appointment of M.I.T. President Killian as Special Adviser to the President for Science and Technology, as recorded on page 97 of this issue.

A native of Denmark, Dr. Bohr has spent most of his career at the University of Copenhagen, where he has been director since 1920 of the Institute for Theoretical Physics, a center which has attracted scientists from all over the world for study under him. When he was only 37 years old, in 1922, he received the Nobel Prize for Physics, in recognition of "his work in the study of the structure of atoms and of the radiation emanating from them."

Photo — Atoms for Peace Awards, Inc.



M.I.T. Music on Record

■ The current vitality and excellence of M.I.T.'s musical life is dramatically symbolized in four Unicorn recordings made at the Institute and released in mid-November. These long-playing records, bringing the total number of Unicorn-M.I.T. recordings to 10, include three organ records – "The Art of André Marchal," and "Beethoven Piano Sonatas," Op. 90 and Op. 101, performed by Ernst Levy, Professor of Music at M.I.T.

These records are the product of a combination that is becoming increasingly familiar at the Institute – a world-famous visiting artist working with M.I.T.'s own musicians and making use of recording facilities in Kresge Auditorium and the M.I.T. Chapel. In this case, the visiting artist is renowned André Marchal, organist at the Church of St. Eustache in Paris.

Institute musicians who contributed to the making of the records include students and members of the research staff and Faculty belonging to the M.I.T. Choral Society. When Mr. Marchal heard the Choral Society perform Bach's "St. John's Passion," he was so impressed that he requested their participation in his recordings. So the M.I.T. Choir was organized and sang Gregorian chants on two of Marchal's records. The choir is conducted by Professor Klaus Liepmann, Director of Music at M.I.T., and author of the program notes on the Marchal records.

Professor Levy – composer, pianist, and Faculty resident – has contributed more to music at the Institute than one could appreciate even from hearing his masterful recordings. Edward T. Canby has this to say of him: "Ernst Levy is a 'big' pianist and a Beethoven man through and through. . . . Put on his 'Appassionata' and you'll soon find out why he is what he is."

The excellent acoustics and unique design of the M.I.T. Chapel and Kresge Auditorium suit equally well the requirements of performers, listeners, recording engineers, and record owners. The Unicorn recordings are a breath-taking illustration of cooperation between a fine organ builder, acoustics experts (Messrs. Richard H. Bolt, Leo L. Beranek, and Robert B. Newman, '49, of M.I.T.), and a thoughtful architect, Eero Saarinen. The two Holtkamp organs were designed specifically for the Kresge Auditorium and the M.I.T. Chapel. Mr. Marchal takes advantage of the contrast between the large, versatile Kresge organ and the "small form" Chapel organ by playing appropriate sections of the Bach "Klavier-Ubung," Part III, on alternate instruments.

The three volumes of "The Art of André Marchal" are: Volume 1 (UNLP 1046) J. S. Bach, Klavier-Ubung (Part III); Volume 2 (UNLP 1047) Masters of French Organ Music; Volume 3 (UNLP 1048) J. S. Bach and His Predecessors.

Other long-playing records in the "Music at M.I.T. Series" include: "The Modern Age of Brass" by Roger Voisin and his Brass Ensemble; "Handel Organ Concertos" by Lawrence Moe and the Unicorn Concert Orchestra, conducted by Professor Liepmann; and recordings of piano sonatas by Haydn, Beethoven, and Liszt—all played by Professor Levy.

On the Horizon

December 7, 1957 – 11th M.I.T. Alumni Regional Conference, Pittsburgh, Pa. **Speakers:** Deans E. P. Brooks, '17, and George R. Harrison; Professors Jerrold R. Zacharias, Irwin W. Sizer, and Morris Cohen. (For further information, consult Thomas I. Stephenson, 3d, '45, Aluminum Company of America, Pittsburgh 19, Pa.)

February 4, 1958 – Midwinter Meeting of Alumni Association, M.I.T. Campus in Cambridge.

March 1, 1958 – 12th M.I.T. Alumni Regional Conference, Washington, D.C. (For further information, consult T. K. Meloy, '17, 3000 Arlington Boulevard, Falls Church, Va.)

March 13-15, 1958 – 10th Annual Fiesta, M.I.T. Club of Mexico, Mexico City, D.F. (For reservations, consult Clarence M. Cornish, '24, Margaritas 139, Villa Obregon, Mexico 20, D.F., Mexico.)

June 16, 1958 – 24th Alumni Day, 1958, M.I.T. Campus in Cambridge.

Stuart Edgerly: 1903–1957

■ Stuart Edgerly, Assistant Professor of English and History in the Department of Humanities, died at the Institute on October 9. He was 53 years old.

A member of the Institute's Faculty since 1942, Professor Edgerly was born in Omaha, Neb., and received his A.B. at Dartmouth College and his A.M. at Harvard University. From 1930 to 1942, he served as instructor in English at Syracuse University, Suffolk University, and Northeastern University.

He was a member of the Modern Language Association of America and the American Association of University Professors.

Professor Edgerly, who lived in Sudbury, is survived by his wife, Florence, and by two sons – Stuart, Jr., '46, and William S. Edgerly, '49.

William A. Wilson: 1913–1957

■ William A. Wilson, Professor of Mechanical Engineering at M.I.T., died on November 2. He was 44 years old. A native of Richland Center, Wis., and a graduate of Columbia University, Professor Wilson joined the M.I.T. Faculty in 1949 as associate professor and was promoted to a full professorship in July of this year.

His 15 years' association with research and development in American industry began with a 1934 appointment as experimental engineer at Westinghouse Electric Corporation. During and after World War II, he was development engineer and mechanical division engineer in charge of gas turbine developments at the Elliott Company.

Professor Wilson is survived by his wife, the former Eleanor Lawson, and by four children – Carla L., Kathryn H., Grant M. and Douglas J. Wilson.

Metropolitan Photo

On this and the opposite page members of the Class of 1932 may be viewed as they celebrated their 25th reunion on the week end of June 7-9, culminating with Alumni Day activities on June 10. Most of the class reunion events were held on the M.I.T.

Individuals Noteworthy

■ Prominent in the autumn news have been the 32 alumni promotions, elections, or appointments enumerated below:

Irving W. Wilson, '11, as Chairman of the Board, Aluminum Company of America . . . *Leo I. Dana, '17,* as Vice-president of Research and Development, Linde Company Division, Union Carbide Corporation . . .

Philip B. Craighead, '18, as President, Magnesium Association . . . *Latimer F. Hickernell, '22,* as Vice-president of Engineering, Anaconda Wire and Cable Company . . .

Fred C. Koch, '22, as a Director, Northern Natural Gas Company . . . *Harland C. Forbes, '23,* and *C. Wesley Meytrott, '27,* respectively, as Chairman of the Board and Vice-president in Charge of Sales, Consolidated Edison Company of New York . . .

Edward J. Healy, '23, as Vice-president of Construction, Kuljian Corporation . . . *Avery H. Stanton, '25,* as Treasurer and Vice-president, Post Products, Inc., of Auburndale, Mass.

Chester F. Buckley, '26, as President and General Manager, Standard Transformer Company . . . *Theodore A. Mangelsdorf, '26,* as a Senior Vice-president, Texas Company . . .

Charles H. Topping, '28, as President, Building Research Institute . . . *John J. Wilson, '29,* as a Director, Second Bank-State Street Trust Company, Boston . . .

Henry N. Bates, '30, as Vice-president, Johns-Manville Products Corporation . . . *Richard T. Kropf, '31,* as President, American Society for Testing Materials . . .

Gilbert M. Roddy, '31, as Executive Vice-president, Boston Manufacturers Mutual and Mutual Boiler and Machinery Insurance Companies . . . *Oscar T. Marzke, '32,* as Vice-president, United States Steel Corporation . . .

Lewis W. Moore, '33, as President, American Oil Company . . . *Newland F. Smith, Jr., '33,* as President, Gray Research and Development Company . . .

Robert H. Winters, '33, as President, Rio Tinto Mining Company of Canada, Ltd. . . . *Timothy J. Coleman, '34,* as Vice-president, Union Carbide Development Company . . .

Edmund Q. Sylvester, 2d, '34, as President, American Ship Building Company . . . *César A. Calderon, '36,* as a Director, Government Development Bank for Puerto Rico . . .

W. Gardner Barker, '37, as Executive Vice-president, Thomas J. Lipton, Inc. . . . *Paul A. Vogel, '37,* as Treasurer, Underwood Corporation . . .

Campus, with headquarters at Baker House. James R. Killian, Jr., '26, M.I.T. President, gave the welcoming address at the banquet on June 8, pictured above at the Faculty Club. Professor Rolf Eliassen was chairman of the Reunion Committee.

Willard F. Babcock, '39, as Director of Highways, State of North Carolina . . . *Maxwell C. Coutts, '39,* as President, Canadian Society of Industrial and Cost Accountants . . .

Julius P. Molnar, '40, as Vice-president, Bell Telephone Laboratories . . . *David T. Morgenthaler, '40,* as President, Foundry Services, Inc., of Columbus.

Samuel K. McCauley, '41, as President of Iricon Agency, Ltd., which represents nine American oil companies in the Iranian Oil Consortium . . .

Robert L. Purvin, '41, as Vice-president, Foster Grant Company of Leominster, Mass. . . . *Albert F. Clear, Jr., '42,* as Vice-president, John B. Stetson Company.

■ Special honors to Alumni include:

To *James C. Kimberly, '94,* an honorary doctorate of laws, by Lawrence College . . . to *Alfred P. Sloan, Jr., '95,* the Frank H. Lahey Memorial Award for his service as a layman to the cause of medical education, presented jointly by former President Hoover, the Presidents of the American Medical Association, and the Association of American Medical Colleges . . .

To *Herbert J. Ball, '06,* an honorary doctorate of science, by Lowell Technological Institute . . . to *J. Newell Stephenson, '09,* an honorary doctorate of science, by the University of Maine . . .

To *William H. Martin, '11,* an honorary doctorate of science, by Johns Hopkins University . . . to *Robert E. Wilson, '16,* a Distinguished Service Citation, by the Automotive Old Timers . . .

To *Lewis W. Douglas, '17,* an honorary Knight Grand Cross of the Order of the British Empire, by Queen Elizabeth II . . . to *Thorndike Saville, '17,* an honorary doctorate of science, by New York University . . . to *Philip C. Rutledge, '33,* an honorary doctorate of science, by Purdue University.

■ Among the Alumni to whom birthday congratulations are appropriate during this month are two who are due to celebrate their 90th anniversaries, 10 their 85th, and two their 80th, as listed below with their respective dates of birth:

December, 1867 – *Lucretia M. Churchill, '96,* on the 8th; and *Henry R. Hayden, '90,* on the 16th.

December, 1872 – *Edward A. Eames, '96,* on the 5th; *Arthur W. Tidd, '94* on the 9th; *George W. Sherman '94,* and *John S. Eynon, '96,* on the 10th; *Victor Shaw, '96,* on the 12th; *Karl A. Pauly, '96,* on the 18th; *Luther Conant, '95,* on the 21st; *Lawrence W. Jenkins, '00,* on the 23d; *Arthur S. Rogers, '94,* on the 29th; and *John J. McSorley, '97,* on the 30th.

December, 1877 – *James G. Leiper, Jr., '99,* on the 19th; and *Salvador Madero, '00,* on the 31st.

Twenty-five Years Ago This Month . . .

■ Technology's annual fiscal report by Treasurer Everett Morss, '85, covering 1931-1932, showed that the Institute's net operating and expense figures had exceeded the three million mark for the first time and that, in a year of financial stress when many educational institutions incurred heavy deficits, the Institute expended but $15,575 above its receipts.

Mr. Morss reported that on the previous June 30 the book values of the Institute's "land, buildings, and equipment" and its "endowment funds" were recorded, respectively, as being $15,706,341 and $32,651,408. Capital gifts, exclusive of those to establish the Technology Loan Fund, totaled $1,582,355 during 1931-1932.

Since the $500 tuition rate became effective for 1931-1932, income from students was $1,589,668, an increase of 20 per cent compared with 1930-1931; but income from invested funds was $1,238,346, a drop of nearly 5 per cent.

■ Registrar Joseph C. MacKinnon, '13, according to his annual census of the student body made November 1, found that the 1932-1933 registration totaled 2,831, a drop of 357 or 11 per cent, from 1931-1932. The entering Freshman Class of 1936 numbered 561, or 67 less than the entering Freshman Class of 1935. Included in the 561 of the Class of 1936 were about 100 who matriculated under the "new plan permitting the entrance of a limited number . . . without examination, provided they have graduated in the upper fifth of their class in an accredited secondary school, and can enter with a clear record in all subjects required for admission."

Reminiscent of the work in high-speed photography in the 1930's is this photograph of a hammer blow as it shatters glass, caught by Harold E. Edgerton, '27, Professor of Electrical Measurements at the Institute.

■ Congratulations were being extended to *Alfred P. Sloan, Jr., '95,* for becoming chairman of a group of 76 industrial leaders organized as the Committee for the Consideration of Inter-Governmental Debts; . . . to *Paul W. Litchfield, '96,* for being the second person to receive the "Spirit of St. Louis" aeronautical medal; . . . to *John Taylor Arms, '11,* President of the Society of American Etchers, for presenting to President Hoover a portfolio of the works of 20 United States etchers illustrating "important steps in the mental and executive growth of George Washington"; . . . and to *Joseph W. Barker, '16,* upon his election to the Presidency of the Illuminating Engineering Society.

Happy Birth Day!

■ Because the number of married students at the Institute has increased sharply in recent years, M.I.T. has entered into an agreement with the Boston Lying-In Hospital which will provide complete obstetrical care for M.I.T. students' wives. The plan, which is believed to be a pioneering program of its kind, was recently announced at a meeting of the M.I.T. Dames (an organization of student wives) by President James R. Killian, Jr., '26. Although the costs of the plan are borne by the student, the program guarantees excellent care at a fixed and minimum charge.

The agreement provides for complete prenatal care in the M.I.T. Medical Department, including all necessary laboratory work and the services of consultants, all medical care required at the Boston Lying-In Hospital and hospital charges for seven days, and *post-partem* follow-up at M.I.T.

About 1,000 of M.I.T.'s 6,000 students are married. These married students currently have about 1,000 children and it is estimated an additional 200 children will be born this year.

Dr. Ruby Jackson, a member of the visiting staff at B.L.I., has been appointed to the staff of the M.I.T. Medical Department, to head the new service. She will participate in both the prenatal and *post-partem* clinics at M.I.T. and will supervise the operation of the program at B.L.I.

In commenting on the plan, Dr. James M. Faulkner, Head of the M.I.T. Medical Department, noted that the majority of students are living on a minimum income and that most at M.I.T. come from other parts of the country or from abroad. "This new plan," he said, "is a means of providing the highest quality obstetrical care at minimum cost."

Dr. Jackson, who is the first obstetrician to be appointed to the M.I.T. medical staff, took her undergraduate work at Mount Holyoke College and her medical degree at McGill University. Besides being associate obstetrician at B.L.I., she is also associated with the Boston City Hospital and the Free Hospital for Women.

M.I.T.-Harvard Synchrotron Begun

■ Building of a six billion electron volt accelerator in Cambridge formally began on November 4 with ground-breaking ceremonies in which J. A. Stratton, '23, Chancellor of M.I.T., and Nathan M. Pusey, President of Harvard University, took part.

The new accelerator, which will ultimately produce the fastest nuclear particles yet achieved by man, is being designed and will be operated jointly by scientists of the Institute and of Harvard University. The contract for the accelerator will be administered by Harvard University. This $6,500,000 contract for the new research instrument was signed last spring by the Atomic Energy Commission.

Construction under the A.E.C. contract is expected to take more than two years. Initial operations of the new accelerator are planned for January, 1960. When completed, the Cambridge Electron Accelerator will be the most powerful electron accelerator in the world. The new accelerator will be devoted to basic, unclassified research on the properties of the sub-nuclear particles and of the forces which hold the nucleus together. It will be located near the Harvard Cyclotron.

The new machine – a synchroton – will accelerate electrons to very nearly the speed of light and in the process will increase their mass by 12,000 times. At this speed, these electrons and the super-energy x-rays which they produce will be able to break apart the protons and neutrons which are building blocks of atomic nuclei. Studies with this new research tool will make possible important new knowledge about the properties of the sub-nuclear particles and of the forces which hold nuclei together. It is those forces which supply the energy released in nuclear fission or fusion and which promise untold new sources of power for the future.

The circular tunnel building for the accelerator will be placed below ground, sheathed in concrete and with a five-foot earth-fill over the top. Heavy concrete blocks forming a portion of the wall can be arranged to allow narrow beams of radiation to emerge from the synchrotron into the large experimental building where research experiments will be located. This heavy shielding will eliminate any possible radiation hazard from the high-energy electron beam.

A dozen accelerator scientists and engineers are carrying out the basic design for the synchrotron under the direction of M. Stanley Livingston, Professor of Physics at M.I.T. About 20 scientists from M.I.T. and Harvard are assisting as advisers in the design planning.

The executive committee to set policy includes: Dean McGeorge Bundy of Harvard, chairman; Major General James McCormack, Jr., '37, Vice-president for Industrial and Governmental Relations at M.I.T.; Professor Martin Deutsch, '37, of M.I.T.; Professor Nathaniel H. Frank, '23, of M.I.T.; Professor David H. Frisch, '47, of M.I.T.; Professor Edward M. Purcell of Harvard; Professor Norman F. Ramsey of Harvard; Edward Reynolds, Administrative Vice-president of Harvard; Chancellor J. A. Stratton, '23, of M.I.T.; and Professor J. C. Street of Harvard.

Industrial Relations

■ The 20th anniversary of the Industrial Relations Section at the Institute was celebrated on November 1 with a high-level conference on "The Next Twenty Years in Industrial Relations."

The M.I.T. Industrial Relations Section, a division of the Department of Economics and Social Science in the School of Humanities and Social Studies, is the third oldest center of its kind in the country.

The conference was attended by invited guests, including about 225 company, union, and academic personnel with a special interest in the M.I.T. industrial relations program. Principal talks at the morning and afternoon sessions included:

"What Will Collective Bargaining Look Like in Twenty Years?" by George W. Brooks, Director of Research and Education, International Brotherhood of Pulp, Sulphite and Paper Mill Workers; "The Utilization and Development of High-Talent Man Power in American Industry," by Frederick H. Harbison, Director, Industrial Relations Section, Princeton University; "Protecting the Civil Rights of Union Members," by Clark Kerr, President, University of California; "Trends and Future Problems in Collective Bargaining," by Leland Hazard, Vice-president and General Counsel, Pittsburgh Plate Glass Company.

Secretary of Labor James P. Mitchell delivered the principal address at the closing session of the conference in Kresge Auditorium on Friday evening, November 1. Mr. Mitchell's talk on "Looking Ahead in Industrial Relations in the United States" was open to the public.

Regarding the important problem of use of high-talent man power in a technological society, Dr. Harbison's remarks are abstracted as follows:

It is obvious that the trend in modern industry is to consume more and more brains and less and less brawn. All kinds of technological change increase the proportionate requirements for high-talent personnel – for scientists, mathematicians, engineers, chemists, administrative staff specialists, and high-level managers. Automation always increases the requirements for brain power; its principal human consequence is not the displacement of people but rather the increasing quantity of high-talent man power which it consumes. Wherever innovations are made – in new products, new processes, new techniques of control, new methods of marketing, or new ideas in management – there is need for highly trained technical man power. . . .

Much of management's effort in the past has been directed toward treating the common man fairly and equally. But the skills and concepts which have been useful in dealing with the common man are not always those most appropriate for dealing with high-talent man power. . . .

If management can solve these problems there is good reason to expect that professional personnel will *not* be organized. It is significant that the few unions of engineers and scientists which exist today have as one of their major goals in bargaining the recognition of the professional interest and status of their members.

A proposal for management-induced strikes was made "without ill-will or belligerency" at the conference by Leland Hazard. Mr. Hazard told the audience of business, labor and academic leaders that inflation is the great issue of our time and that management has the duty to halt inflation by saying no to union demands for wage increases.

"Because of the wage inflation spiral," Mr. Hazard declared, "the American system itself is in jeopardy." He expressed little sympathy for those who think inflation can be held to a perpetual, innocuous, not to say beneficial, creep. "In a common-sense American way," he said, "most of us reason that there must be a top, and that even a creep can lift us in time to a dizzy zenith from which a fall could be fatal. . . . Management must begin now to refuse wage increases even though we know certainly that our refusal will produce strikes. . . ."

Mr. Hazard told his M.I.T. audience: "I believe that top-level labor and top-level management and top-level government must come together in an open public, widely publicized conference – one in which all masks come off, all pretenses are abandoned in a collaborative search for the key to greater capitalistic success – perhaps the key to the salvation of capitalism."

Mr. Mitchell stated that the shortage of scientists and engineers is front-page news; but equally important is the shortage of labor, people who can put the engineers' and scientists' ideas into effect. Unions have fallen down in one area of their responsibility: there should be an increase in the numbers of union members; he did not mean that all labor should be unionized, but he would like to see growth "based upon the recognition of laborers that they want to – and will benefit from – joining." Trade union leaders must always feel they are dealing with human beings (this in contrast to management, which does not deal exclusively with human problems); "we must preserve individual freedom and rights, must resist every move that tends to make man part of a mass."

Biosciences and Satellites

■ The first meeting of the Alumni Council for the current year – the 326th such meeting to be held – took place at the M.I.T. Faculty Club, Sloan Building, on Monday, October 28. Gilbert M. Roddy, '31, President of the M.I.T. Alumni Association, opened the dinner meeting which was attended by 177 members and guests.

As usual, matters of business occupied the first portion of the meeting, but the two speakers featured on the program delivered talks of particular interest and timely importance. Professor Richard H. Bolt of the Department of Electrical Engineering, and now on leave of absence from the Institute to assist in the expanding work of the National Institutes of Health, spoke on "New Trends in Biophysical Science." H. Guyford Stever, Associate Dean of the School of Engineering, chose "Satellites" as his topic.

In his key position as principal consultant to the Study Section on Biophysics and Biophysical Chemistry of the National Institutes of Health, Dr. Bolt is responsible for the planning and co-ordination of a new program aimed at stimulating and developing, on a national scale, the rapidly growing field of biophysics.

The application of the physical and engineering sciences to the investigation of the life sciences is opening up ever-expanding horizons in biomedical research. The National Institutes of Health has recently placed substantial funds at the disposal of the Study Section to stimulate research and training in biophysics. Dr. Bolt told how this program stimulated teaching and research in biophysics, enumerated the benefits resulting from the interchange of ideas and information on an inter-disciplinary basis, and alluded to some of the work being done on these fronts by members of the M.I.T. Faculty.

Dr. Stever, formerly Chief Scientist of the U.S. Air Force, related that some of the earliest technological progress in rocketry and space travel had been made by Russian scientists. American pioneers in this field were fewer in number than should have been the case. During World War II, the Germans took the lead in developing rockets for military purposes. Following World War II, the United States and the U.S.S.R. both benefited from German progress in rocket developments. The Russians themselves have made remarkable scientific progress, and Dr. Stever felt it was an error to underestimate the technological ability of Russian scientists.

Because the Russian scientists have lived up to essentially all the claims they have made in the past with respect to A- and H-bombs, Sputnik, and Inter-Continental Ballistic Missiles, Dr. Stever believes that we, in the United States, should no longer discredit the current Russian statement about their Sputnik and other rocketry advances. In his opinion, the Russian scientists are tops in this field.

Earlier, in the business portion of the meeting, Donald P. Severance, '38, as Secretary of the Association, announced that: (1) between April 22 and October 25 visits had been made to 26 different M.I.T. clubs in all parts of the world, by 16 different members of the Council or M.I.T. staff; (2) a new M.I.T. Club of Colombia had been established; and (3) that Regional Conferences were to be held this year (1957-1958) in Pittsburgh and in Washington, D.C. In addition, Mr. Severance reported changes in class affiliation, membership of Visiting Committees, newly appointed class and club representatives on the Alumni Council, and the fact that the Executive Committee had voted to increase the number of associates on the Alumni Council from 35 to 50.

As chairman of the Alumni Fund Board, Dwight C. Arnold, '27, announced that, as of October 25, slightly more than 1,500 Alumni had already contributed $47,000 to this year's Fund. This year personal solicitations will be carried out in 135 areas, in contrast to the 73 regions set up last year.

In the absence of Charles E. Fuller, '92, George Owen, '94, presented a report for the Committee on Resolutions for the late Harry J. Carlson, '92. President Roddy called upon the members present to accept the resolution by a rising vote.

Following an extensive period of questions on rocketry, space travel, and missiles, the meeting was adjourned at 9:55 P.M.

William Barton Rogers

In an address at William and Mary College on the life of the founder of M.I.T., President Killian reminds us that: "If we are to survive as a nation, science most certainly will play an increasingly large part in our national life."

by JAMES R. KILLIAN, JR.

As a native southerner I find special satisfaction in returning to the South to represent today the Yankee institution that was created by an alumnus and former professor of William and Mary. I bring greetings from M.I.T. to William and Mary, and express the privilege and pleasure which we feel in Cambridge in joining this gracious tribute to the remarkable man in whose fame both institutions share.

As my share of this tribute to William Barton Rogers, I wish to recall the ways in which his student, teaching, and professional experiences in the Commonwealth of Virginia shaped his ideas and career and foreshadowed the institution he fathered in the Commonwealth of Massachusetts. I then wish to show, in conclusion, how Rogers foresaw with prophetic vision the educational needs of the United States today and how some of the ideas he fathered, and not yet fully utilized, are still needed if our education is to meet the needs of Twentieth-Century America.

And speaking personally, I experience sentiments of delight and gratitude and humility, as I receive your generous accolade, accepting it as an expression of your esteem for the institution I head. You do honor to that institution in permitting me to stand here in this "shrine of learning and inspiration" associated with the memory of scholars, patriots, and statesmen.

It was indeed Virginia that nurtured Rogers and cared for him and gave him the field of action that brought him to scientific and educational maturity. It was in this Commonwealth that he became state geologist, and successively professor of natural philosophy at William and Mary and the University of Virginia. The realization of his plan for polytechnic education, emphasizing the application of science, was to come with the founding of "Boston Tech" in 1861; yet it was here in Virginia that his scientific and educational beliefs came into focus.

In 1828 upon introducing his first course in natural philosophy at William and Mary, Rogers stated:

> I would solicit your attention to the views which I shall present in illustration of the history, nature, and utility of Physical Science generally. . . . In presenting these views, I propose—
> *First*, to allude to the relative proficiency of the ancient and modern world in Science and the Arts
> *Secondly*, to exhibit some general ideas in relation to the material world, and
> *Thirdly*, after defining the science of Natural Philosophy and tracing the events which separate it from Chemistry, to adduce a variety of illustrations to evince its utility.

Here are the seminal ideas which were to give direction to Rogers' later educational philosophy – his humanistic view of science, his use of the historical approach, his fusion of pure and applied science, and of the cultural and utilitarian values.

While breaking unharrowed ground in educational theory, Rogers simultaneously did creative work as a scientist. He was a true naturalist, as the Nineteenth Century understood the word, with interests covering many more specialized areas. In his early years his work centered around chemistry and physics. But, his fame rested upon convincing American geologists that the time had come to turn from purely descriptive work and to venture into dynamic geology. The theories of William and his brother Henry, upon the unfolding of the Appalachian mountain chain, have in the main survived the test of a century. Throughout his life Rogers had a keen interest in the development of national societies as a means of strengthening the scientific professions. He not only assisted in the organization, but also served as president of both the American Association for the Advancement of Science and the National Academy of Sciences. However, his most important role was in the enlargement of the concept of technological education.

Colonial America fully shared the Seventeenth-Century faith that natural science would prove to be the relief of man's estate. Those American scientists, few in number and usually either planter, merchant, or cleric by profession, could on occasion concern themselves with the general theories of science. Yet on the whole they were inclined, by the pressing problems of survival, conquest of the wilderness, and adjustment to their fellow men, to be more concerned with its utilitarian aspects. Ingenuity was displayed in applying scientific principles to inventions designed to control nature, promote human comfort, and make a profit.

By 1825, interest in natural science no longer was the esoteric concern of the learned men and the cultivated few: it was the concern of all. The economic expansion of the country, the gradual opening of the West, and the growth of industries, greatly increased the need for a deeper knowledge of the resources of the nation. What treasures were buried in its rocks,

Courtesy of College of William and Mary

Scene at the College of William and Mary much as it must have been when William Barton Rogers began his teaching career in Williamsburg, Va.

hidden in its soil, lurking in the molecules of matter? How could nature be controlled to offer better opportunities for man? But the existing educational institutions were still inadequate in facilities and qualified personnel to meet these demands.

College education was still centered upon the study of the classics. Natural science was considered of relatively little importance, in comparison, except for mathematics. The colleges, as a rule, still believed that for "training the mind," Caesar, Plutarch, and Euclid were unsurpassed. Applied science as a part of the college curriculum was almost nonexistent. A few schools, notably Yale and Williams, had hesitantly and half-heartedly attempted to teach the application of scientifio principles to the productive arts. Rensselaer Institute under Amos Eaton and the United States Military Academy under Sylvanus Thayer had already pioneered in the training of science teachers and civil engineers, respectively. The United States was definitely lagging in technological education relative to Europe where engineering had long been recognized as a profession. The Ecole Polytechnic in Paris, the Bergakademie at Freiburg, the Technische Hochschule in Zurich – all had already achieved a highly intellectual, scientific and analytical approach to education for the technological services demanded by state and industry.

The part played by southern institutions in the beginnings of scientific education in the United States has only recently been recognized by historians. At William and Mary particularly, long before the Revolution, a higher and more thorough education was available than perhaps anywhere else in the American colonies. The College, since the establishment of its first Chair of Natural Philosophy and Mathematics in 1712, had charted the path of scientific education. This was particularly manifest under the tutelage of Dr. William Small who, as a physician and professor of natural science at the College from 1758 to 1764, was the enemy of all narrow dogmatism of the classical education. Thomas Jefferson said of him: "He fixed the destinies of my life." Dr. Small innovated the lecture system at William and Mary, and, it is believed, in all America as well, a crucial break with the traditional method of pure memory lessons and recitations by question and answer, thus adding another to the long list of educational priorities at William and Mary. It is interesting to note that the introduction of the lecture and demonstration method in the Chemistry Course at Harvard did not occur until 1851, some 90 years after its introduction at William and Mary.

These distinctive features of William and Mary must have exerted an influence upon Rogers when he entered as a student at the age of 15 in 1819. His father, Patrick Kerr Rogers, M.D., in the meanwhile had been elected to the Chair of Chemistry and Natural Philosophy at the College, a worthy successor to men like Small, Bishop James Madison, and Robert Hare, who made important contributions to early American science.

Thoroughly dedicated to education and science, Rogers left his home and the college in 1825, a most propitious time. The United States was a scene of feverish ferment, both politically, economically, and socially. The cultivated physicians, merchants, planters, and ministers, whose avocation was science were being succeeded with professional scientists and men were beginning to find a career in science. Devoting their entire time to laboratory and field work, this group was being given increasing support by colleges and government. Equally important was the growing awareness by people from all walks of life that science promised a better life. The contagious interest in the popularization of science, evidenced in the Lyceums and the Mechanics' Institutes,

now enabled men of science to earn money as lecturers. The promotion and organization of science resulting from the growing spirit of professionalism, from patriotic zeal for achievements, and from the needs of commerce would alone have constituted a new chapter in the history of American science. But the increasingly close collaboration between scientists and practical men and the quickened tempo in applying scientific principles to the practical arts heralded a new era. The day of the machine and technology were at hand.

It was a fortunate turn of circumstances that led Rogers first to seek employment in Baltimore after his student days at William and Mary. There, the citizens gave ardent support to the movement in scientific education for laymen which had been sweeping the large cities since 1820, and Rogers rode the wave of this enthusiasm.

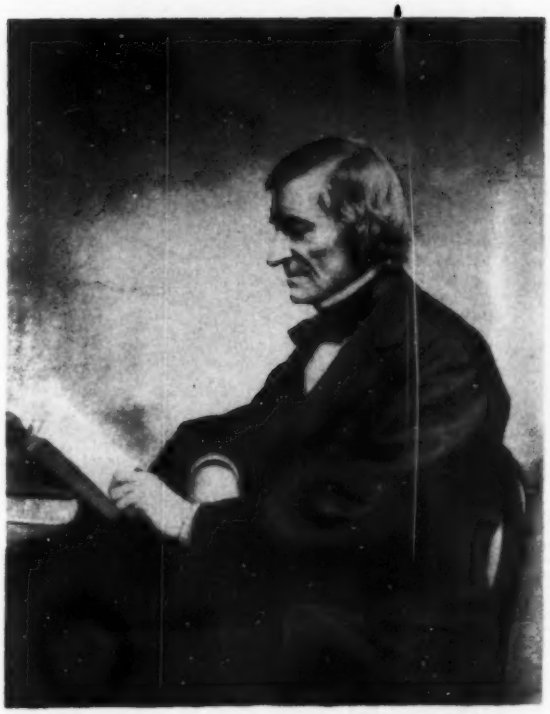
The Maryland Institute, with a most successful patronage of its library, geological cabinet, philosophical equipment, and lecture series, provided fertile ground for Rogers' talents and for developing his appreciation of the social values of applied science. By 1828 he was offering a lecture course on railroads which apparently captured current interest in internal improvements.

Not content to reach only the adult population, Rogers presented a comprehensive proposal to the Maryland Institute for a new type of high school; the framework of his plan is still evident in vocational high schools today: aiming "to impart such knowledge and to induce such habits of mind as may be most beneficial to youth engaging in mechanical and mercantile employments – the study of mathematics to be an object of primary attention." Circumstances affected Rogers' future at this point. Upon the death of his father in 1828, he was elected to the Chair of Natural Philosophy and Chemistry at William and Mary, thus diverting him from carrying out his plans for secondary education.

For seven years Rogers served his alma mater as one of its most distinguished faculty members. In 1830 it is recorded that his classes were the largest in the College. His concern for yoking science with technology is evident from the description of the senior natural philosophy course which embraced "Dynamics, Mechanics, Electricity, Meteorology, together with the practical subjects of materials, the construction of the watch and clock works, of roofs, arches, bridges, roads, the steam engine, and elementary principles of architecture." That must have been quite a course!

Rogers — the Geologist

Fired by the zeal of his brother Henry, Rogers in 1833 turned his research from physics and chemistry to the field of geology, his chief scientific interest for the remainder of his life. Early American geology had been confined mainly to observation and classification, with constant debate between the Neptunists and the Vulcanists as to origin of the earth's surface. Rogers, along with Agassiz, Silliman, and Dana, pioneered original theories of dynamic geology. Rogers' most noteworthy contributions in geology



Portrait photograph of William Barton Rogers as he appeared while serving as first president of M.I.T.

were upon the physical structure of the Appalachian mountain chain and the tertiary formation of Virginia. His interpretation of the mountain-forming processes still largely holds today.

By the end of the second decade of the Nineteenth Century, the economic expansion of the country, with its growth of industry, agriculture, and mining, called for a wider use of science. Interest came not only from utilitarians, but also from enthusiasts for education, for knowledge, and the cultivation of the arts and sciences. These groups pressed the national and state legislatures to furnish funds for the support of research into the natural resources of the nation, with geological surveys perhaps the most important single demand.

It was only fitting that Virginia in 1835, following the earlier examples of Massachusetts, New Jersey, and North Carolina, should appoint William Rogers its leading Scientist, to head the Virginia State Geological Survey. For six years, until the legislature declined to appropriate funds, Rogers vigorously planned and prosecuted the exploration and mapping of the mineral resources of the state, while also carrying heavy academic and administrative responsibilities at the University of Virginia where he had been elected professor of natural philosophy in 1835. Considering the conditions under which Rogers traveled and studied the Virginias, his accomplishments assume heroic significance. Roads were few, maps were of a most general nature and scarce, and insufficient means were available to carry on proper field and laboratory studies. Yet, the results of the survey greatly stimulated the development of Virginia – and would have been more marked had it

The first Rogers Building, built on Boylston Street in Back Bay, Boston, served as the Institute's main academic building from 1870 to 1916. Students in the Department of Architecture used the old Rogers Building until 1938 when the new Rogers Building was built in Cambridge.

not been for the Civil War. Perhaps a more tangible effect of the Survey was upon Rogers himself, as it brought him into public notice and contact with fellow professional scientists, to broaden his own horizons regarding the interrelation of science and the social and economic environment, and to stimulate a dissatisfaction with his own narrow professional field with results of the highest benefit to education.

Since his move to the University of Virginia, Rogers had become immersed in college administration, for in 1844 he was chosen chairman of the faculty. This position strengthened Rogers' administrative and organizational skills, while affording him full opportunity to ponder Jefferson's educational ideas of universal education, stressing the use of science and technology for the betterment of society.

In this period of heavy responsibility, Rogers was thinking deeply about technological education and a grand plan for a new kind of institution was taking shape in his mind. It became apparent to Rogers that only through the formation of a new school, free from the vested interests of traditional education, devoted specifically to polytechnic education, could science and its practical application be placed in its proper perspective in the general system of American education.

It was not lack of loyalty nor respect for Virginia or its university that led Rogers to view Boston as the site for consummation of his ideas on polytechnic education. That city, with its flourishing arts and sciences, the center of factory- and machine-conscious New England, and philanthropic-minded families, was a logical location for a school devoted to technology. Such circumstances led Rogers in 1846 to prepare his famous "Plan of a Polytechnic School."

The proposal attracted nationwide interest, although it was not until 1861 that Rogers saw its culmination when the "Act to Incorporate the Massachusetts Institute of Technology" was passed by the Massachusetts state legislature "for the purpose of instituting and maintaining a society of arts, a museum of arts, and a school of industrial science, and aiding generally by suitable means the advancement, development and practical application of science in connection with the arts, agriculture, manufacture, and commerce." The forerunner of a new type of educational institution, this was fully tuned to the changing technological character of the nation. It was to serve as the model for many other schools throughout the world. Although difficult to prove, the work of William Barton Rogers undoubtedly did much to pave the way for the Morrill Act of 1861, which led to the establishment of our great and unique system of land-grant colleges.

A New Kind of University

With his plan for a new kind of university Rogers stressed four fundamental principles.

First, he emphasized the importance of being useful. He had no sympathy with the prevailing view that the practical professions lacked dignity, or that utility corrupted liberal education. He was one of the earliest advocates of what James B. Conant has described as the philosophy of the modern American university, "a philosophy hostile to the supremacy of a few traditional vocations, a philosophy moving toward the social equality of all useful labor."

Next, Rogers stressed the educational gain derived from building a college program around a professional objective. He recognized that the discipline, the thoroughness, and the motivation inherent in a professional program have exceptional educational values. Today we see new formulations of this concept in programs such as that recently announced by the Johns Hopkins Medical School in which professional medical education starts after two years of college and general education continues in the upper and graduate years in parallel with professional studies.

Rogers' next principle, that of learning by doing, he expressed through the laboratory method of instruction. While this idea was not original with him, he gave it its first systematic application in America. In his educational thinking, Rogers always stressed method; in a time of skepticism, he had faith in the scientific method. He foresaw the far-reaching effects on higher education of the spirit and method of research, the concept which holds that learning thrives best in an atmosphere of creativeness and not one of imitativeness and antiquarianism. American universities were later to assimilate this idea from the German universities, but Rogers' idea was indigenous.

Next, Rogers was emphatic in his belief that learning principles is more important than learning facts. "We believe," he said, "that the most truly practical education, even in an industrial point of view, is one founded on a thorough knowledge of scientific laws and principles, and which unites with close observation and exact reasoning," and note this, *"a large general cultivation."*

Rogers' emphasis on principles grew out of his practical experience as state geologist in Virgina. In this work he was not content to limit himself to prac-

(*Continued on page 124*)

The Antiquity of Disease

Evidence of disease antedates man's appearance on earth. In less than a century, man has learned how to conquer most of the maladies that have afflicted him for ages

by JAMES A. TOBEY

DISEASE not only is as old as man but older. Maladies were rife upon our planet several hundreds of millions of years before the belated advent of what is politely known as the "human" race. Man was, in fact, a relatively late-comer in the animal life of our world, apparently having begun to evolve only about 1,000,000 years ago. Long before that auspicious event, at least half a billion years ago, the earth was inhabited by numerous other animals; the fishes, the reptiles, and eventually the mammals, many of which are now extinct. These prehistoric animals often were afflicted with disease.

If this statement seems to be a bit reckless, the answer is that it can be supported by scientific evidence. Some of the ailing prehistoric animals were considerate enough to die in places where their remains could be found and examined many millions of years after their demise. Investigations of these skeletons in geological strata and of whole bodies frozen in the ice of the northern tundra have revealed evidence of various diseases, some of them unquestionably of bacterial origin.

The Rachitic Reptile

In the dim and distant geological period known as the Permian, a huge and grotesque reptile called Dimetrodon roamed the plains of Texas, then as now the home of big and exaggerated things. This bizarre creature walked on four stocky legs, had a thick body something like that of a modern crocodile but heavier, with a big fan-shaped crest arising from the top of his back. This adornment looked something like that on the modern sailfish, but was larger and taller. The animal was carnivorous, a hunter of the less voracious reptiles who were herbivorous.

The skeleton of one of these ancient vertebrates, discovered some years ago in Texas, displayed definite evidence of a chronic bone disease, osteomyelitis, which, it is reasonable to assume, resulted from a fracture, with subsequent bacterial infection. Microorganisms were, in fact, found in conjunction with these remains, although their exact nature could not be determined.

The Permian period in which this rachitic Dimetrodon existed is estimated by geologists to have begun about 230,000,000 years ago and to have lasted for about 40,000,000 years. It was the final period of the Paleozoic era of some 300,000,000 years, an era which included the age of the great reptiles, the saurians, practically all of which are now extinct with the exception of a few turtles, snakes, and crocodiles who somehow managed to survive the vicissitudes of the various Ice Ages and the other hazards of the times.

Old Dimetrodon's bone disease, similar to the osteomyelitis which occasionally occurs in modern adults, seems to be the oldest known evidence of disease in any living thing. In the later Jurassic period there lived in England a crocodile whose remains showed an infection of the pelvis which had spread to the legs, the spine, and the palate. This second interesting incidence of ancient disease goes back some 175,000,000 years, plus or minus a few million.

Skeletal remains of the dinosaurs and other gigantic reptiles of the Jurassic period show that these ponderous creatures suffered from a variety of ills, including bad teeth, arthritis, spondylitis, and other abnormalities which can be detected in the bones. Like all animals before and since, they were plagued from time to time with fractures, wounds, and bites which apparently became infected in the ooze of the primeval swamps. Bacteria certainly must have been among the first forms of life on this earth.

By the end of the Mesozoic era, which began about 205,000,000 years ago and lasted a mere 75,000,000 years, all of the gigantic reptiles had become extinct. It is interesting to speculate upon the causes of the decease of these monsters, some of which were 70 feet long and weighed 50 tons or more. It is possible that drastic changes in the climate so altered the existing vegetation that the herbivorous types could not adjust to the new diets, and the carnivorous died out for lack of prey. It has also been suggested that these huge reptiles became biologically overspecialized and succumbed to a racial senescence. Add to these causes the depredations of insects and the ravages of disease, and we can see why the dinosaurs no longer are with us.

Man, the chronic killer of all other animals, including his own species, had not yet appeared upon the scene, but when he did, he too, became the victim of lowly bacteria.

The First Human Disease

About 300,000 years ago there lived upon the earth an ape-like creature who was not a true ape because he stood erect and walked like a man. This primeval

being was about five feet eight inches tall, weighed about 154 pounds, and had straight legs and free-swinging arms. He did not have much of a chin and his forehead receded like that of an ape, but his teeth were distinctly more human than simian. Last but not least, he possessed the outstanding human attribute, a brain, one which was much larger than that of any known ape, but considerably smaller than that of modern man. It is possible that he had the power of speech.

Who was he? The name given to this prehominid by the scientists is *Pithecanthropus erectus,* from the Greek *pithēkos* meaning ape, *anthropus* meaning man, and *erectus* signifying upstanding. The gentleman is also known as Java man because his remains, or some of them, were discovered on the Solo River near Trinil in Java between 1890 and 1892 by a Dutch army surgeon named Eugène Dubois. In deep deposits in this torrid, volcanic region, which had escaped the glaciers of the Ice Age and which had been once joined to Asia by a land bridge, Dr. Dubois discovered a fossilized calvarium or top of a skull, some teeth, a small portion of a lower jaw, and a femur or left thigh bone. Since all these parts were found within an area of about 40 feet, and no other bones were uncovered in the same vicinity, it could be reasonably deduced that they all belonged to one person.

The femur or thigh bone of old Pithecanthropus had upon it an unnatural growth which was examined avidly by the leading pathologists of half a century ago. They were more or less agreed that it was a morbid lesion which had healed. In modern medical jargon this abnormal condition has been described as "extensive exostoses along the lines of the tendinous attachment of the iliopsoas and pectineus muscles." In plain English this means that Pithecanthropus had an abnormal growth on the upper part of the bone where it joins the pelvis, a growth which indicated a chronic infection and thus the presence of bacteria. The same condition occurs occasionally in modern man.

The report of the finding of this ape man aroused such an acrimonious controversy that Dr. Dubois became disgusted with it all, packed up his specimens, and returned to Holland, where he refused to show them to anyone for nearly 30 years. When this priceless collection was finally revealed in 1923 to Dr. Ales Hrdlicka of the United States Smithsonian Institution, it turned out that Dubois had a number of excellent specimens of this most ancient being, although by this time he was convinced that they were the bones of a gibbon. Subsequent investigations in Java disclosed still other remains of Pithecanthropus, who is now generally accepted as an authentic representative of our earliest ancestors and as an indication of man's tremendously long process of evolution.

Many other venerable bones have been, of course, discovered in various parts of the world, such as Heidelberg man, the first known European; Peking man (*Sinanthropus pekinensis*), the earliest Asian; and a large group of prehumans in South Africa, little fellows about four feet tall, who are thought to be at least 1,000,000 years old. Both Heidelberg man and Peking man rather closely resemble Java man, but are considered to be much older, probably about 500,000 years of age. So far, Pithecanthropus seems to present the only reported case of ancient disease.

The Ills of Neanderthal Man

When, however, we come to a much later period, the Stone Age of about 100,000 years ago, we find many more examples of disease in the primitive inhabitants of the times. In 1857 the remains of a prehistoric individual were discovered in the limestone caves at Neanderthal near Dusseldorf in Germany, and since that time his bones have been uncovered in many other parts of Europe. He was a contemporary of the mammoth and the mastodon, the cave bear, the woolly rhinoceros, the saber-toothed tiger, and other mammals now extinct.

Homo neanderthalensis was a brutish, shaggy, low-browed person who walked erect but with a gorilla-like stoop, as shown by his curved thigh bones. His teeth were distinctly human, but his mentality was low and his speech probably consisted mostly of grunts. He was, however, adept at fashioning crude flint weapons and tools and he was an accomplished hunter. He lived in caves, evidently employed fire, and must have had a very precarious existence, especially during the Ice Ages.

The vestiges of this Neanderthal man show that he was afflicted with rickets, arthritis, rheumatism, spondylitis, and dental diseases, and that he suffered from injuries and wounds which became infected and suppurated. About 20,000 years ago he disappeared completely from this earth, and most authorities believe that he was not an ancestor of modern man. When, however, one regards the appearances and the manners of some of the moderns who ride in our big city transit systems, one wonders.

The extermination of Neanderthal man might have been hastened by adverse environmental conditions, such as the climate and the lack of sunshine which promoted rachitic conditions in his womenfolk and made childbearing difficult. It is also possible that the Neanderthalers were attacked and slaughtered by the later Cro-Magnon men, who were bigger and smarter and had better weapons. As in all such instances of man's inhumanity to man, Cro-Magnon may have captured some of the Neanderthal females, so that possibly some of the older strains actually did come down to us. Who knows?

These Cro-Magnon men who appeared in Europe at the end of the last Ice Age resembled modern man in most respects, except that they were more robust and had stronger jaws. They moved into the caves formerly occupied by Neanderthal man and decorated the walls with remarkable pictures in color of animals and hunting scenes and other events. They manufactured flint knives, hand axes, and other tools and artifacts, and they possessed a fairly advanced culture. They buried their dead, worshipped deities, domesticated animals, and undoubtedly were the founders of the first civilizations, probably from 10,000 to 15,000 years ago. They used their brains; they were definitely the ancestors of modern man.

(*Concluded on page 122*)

Science, Technology, and Society

While demanding the benefits of technology, the mass of our population remains in ignorance of the foundations on which our society is based. Progress is inconsistent with the trend toward effortless "education"

by LAWRENCE R. HAFSTAD

WHEN one reads the history of science one has the exhilarating feeling of climbing a big mountain. The history of art gives one an altogether different impression. It is not at all like the ascension of a mountain, always upward whichever the direction of one's path; it is rather like a leisurely journey across hilly country. One climbs up to the top of this hill or that, then down into another valley, perhaps a deeper one than any other, then up the next hill, and so forth and so on. An erratic succession of climaxes and anticlimaxes the amplitude of which cannot be predicted." [1*]

Many of you will recognize the above as a quotation from George Sarton, the eminent historian, and will concur in the idea that in working in science one has indeed the "exhilarating feeling of climbing a mountain." As working scientists, and fully recognizing that we may be naive, we still cling stubbornly to the faith that we are somehow contributing to human comfort and human happiness, and that however stumbling our progress, this progress is upward.

The great acceleration of both science and technology on a world-wide scale since World War II seems to confirm this impression. So does the great increase in suggestions in books, and in articles in journals and periodicals, to the effect that we are on the threshold of a second industrial revolution. Many predictions are extant as to the high standard of living which will be obtainable in a matter of a few decades. The problem of the shortage of raw materials has been emphasized by various writers, but technological ingenuity in the development of substitutes is such that so far as *material* prosperity is concerned, the possibilities do indeed seem limitless.

Much has been written in recent months about the shortage of scientists and engineers. This seems to be a world-wide problem and, as might be expected, is most acute where the development of technology is the most intense. It would seem to be axiomatic that the brave new world of plenty so earnestly desired cannot be attained without an adequate supply of scientists and engineers. To me, and I am sure to many of you, it seems somewhat surprising that so much campaigning and propaganda should be necessary to correct a shortage so obvious. In this area, however disappointing and annoying delays may have been, forces are now beginning to act in the direction to correct the dislocation. This at least is reassuring.

Following not more than a decade or two behind the Russians, in this country and in fact in the Free World at large, we are now belatedly beginning to use a very potent force – the incentive system – to correct the shortage. Once the forces acting can be identified, we can isolate trends and begin to foresee at least the immediate future. Accordingly, since this nation chose not to act on this problem until the shortage was upon us, I will now venture to predict the following sequence of events:

1. A continuation of the current hectic recruiting campaign with increasing salary scales for anyone with a semblance of training in science or technology, and particularly for people with advanced degrees;
2. A marked decrease in emphasis on quality in our schools to meet the increasing popular demand for quantity;
3. A period of progressively diminishing returns to industry and society from the attempt to substitute standardization and quantity for quality in an essentially creative activity;
4. A period of disenchantment with paper credentials as a substitute for education, and finally a renewed appreciation of scholarship and achievement.

There is nothing either profound or new in this cycle. It is an example of the "hunting" process under the action of central forces, which is familiar to all of us. It is interesting, however, to speculate upon the time scale involved.

There is now public recognition of the problem created by the shortage of trained personnel of all kinds. It happens to be, however, just about 10 years since this problem with regard to scientists and engineers had already reached the table-pounding stage on the part of a few forward-looking individuals in Washington, such as Vannevar Bush ['16], Merriam Trytten, and Alan Waterman. We must conclude, then, that in matters of this kind our particular type of society seems to have a time constant – an RC, or response time, if you please – of roughly 10 years. Successive responses to the four impulses listed above can therefore be predicted to require about 40 years! Now it is true that in the historical sense 40 years is not long in the life of a civilization, but one begins to wonder what the time constants are in competitive societies and how such societies are likely to react under similar impulses. Above all,

[1*] Please see numbered references at end of article, page 120.

one wonders why, with our highly developed communications facilities, our response times should be so surprisingly long.

Perhaps no small part of the explanation lies in the fact that scientists and engineers, who have long been aware of this situation, are, after all, a numerically very small fraction of our population. Added to this is the fact that the effects on a society of the activities of this group are invariably long delayed. A complete work stoppage on the part of the creative scientists would not, for example, be felt by our society as a whole for a decade or more. Thus it is difficult for the majority of our population to appreciate fully the function or significance of this relatively inconspicuous group. After all, the larger affairs of our society are, and no doubt always will be (and quite properly), handled by nontechnical people.

It is interesting to speculate about the somewhat anomalous situation into which we have gotten ourselves. There seems to be a tacit, but not clearly expressed, assumption that the purpose of the kind of society we favor is one which gives the greatest good to the greatest number. Our society has seized upon technology as a clearly applicable means to this end, so far as gratifying material wants is concerned. One would then assume that society, or more accurately the nontechnical controllers of that society, would as a matter of enlightened self-interest pay particular attention to the education and training of an adequate supply of what they refer to as "technicians." Instead, it is the technicians, the scientists and engineers, who have been calling for an increase in the supply of talent even though it would be to their own self-interest to restrict this supply of skills and thus improve their bargaining position. As scientists and engineers we ask the question from time to time, "For what and for whom are we working?" The sociologists from whom we assume we should expect a reply seem bewildered that the question should even be asked. By them technology seems to be considered as some extraneous activity apparently introduced or perpetrated by the scientists.

It is this deeper conflict in outlook and attitude between the humanist or sociologist and the scientist or engineer which gives me the greatest concern. The shortage of scientists is serious – but here the incentive forces are being brought into play in a direction to correct the anomaly in due course. However, in the philosophical conflict, with our technology tending to become ever more complex, and with increasing specialization, unless current educational trends are reversed, the technical and nontechnical components of our society will continue to travel diverging paths, with hunting oscillations not of decreasing but of increasing amplitude.

As Sarton has pointed out, "The ominous conflict of our time is the difference of opinion, of outlook, between men of letters, historians, philosophers, the so-called humanists, on the one side, and scientists on the other."[2] Similarly, Mees has stated:

> While the relation between the progress of scientific discovery and the structure of society is of the utmost interest and importance to those who desire to understand it or, still more, to control the changes that are occurring, there is a cleavage between those who follow the discipline of history and of the humanities and those who are eagerly pursuing the quest for scientific knowledge. Humanistic learning is the learning of the ancients; it is a study of the accumulated thought of mankind so far as it has been transmitted to us. Scientific knowledge, on the other hand, is a development arising from the observation of facts and their classification into patterns. The separation of these two types of learning has always been unfortunate; at present it is serious, and it may, indeed, be disastrous.[3]

Many of you will recall that there is a principle in physics which says that in order for energy to be transmitted efficiently from one electrical network to another, it is necessary that there be an impedance match between the two circuits. Very similarly it has been my experience that for the transmission of information, or more accurately human understanding, between two individuals it is necessary that there be a matching of backgrounds. Historically such a matching has not existed between devotees of the humanities and of the sciences. So far as the development and enjoyment of the sciences by and for scientists are concerned, no matching is really necessary. Similarly, the humanities as a discipline are completely self-sufficient. If, however, the humanist chooses to use science as the basis for a technology designed to advance the standard of living of mankind, then it becomes incumbent on the humanist to so fashion an educational system that he can communicate with scientists and engineers. This he has failed and is failing to do. Teaching less science and mathematics and more art and music to scientists may enrich the life of the scientist, but it will not help solve the basic problem of the humanist, which is to create what he has concluded to be the good society. If there is to be a sizable component of technology in his good society, he must face the problem of matching impedances with the scientist.

Let us take a look at some of the facets of this problem which might have to be considered. Very early in my career as a student I became aware of the definition, "Life *is* Struggle," and in my day we were so reactionary that we even came to accept it. It also became clear to me that the struggle was for an intangible something called "Progress." This was a much more elusive concept and one which I have found intriguing even up to this day. Somewhat surprisingly, I learned that the idea of progress was itself a relatively recent concept in human affairs. Still more significantly, it was not accepted without considerable opposition and conflict. People were burned at the stake! All this, of course, is spelled out in the literature and is particularly well summarized in the too-little-known book by Professor Bury.[4] The important fact which emerges, however, is that the idea of progress, and the development of technology, are inextricably interlinked. As stated by Mees, "Technology is at once the source and the justification for the idea of progress."[5] That this is true seems to be accepted by scholars throughout the world as is evidenced, for example, by the determination of the underdeveloped countries to industrialize. The fact seems to be accepted everywhere except where it should be most obviously true and that is here in our own United States. Here in our society we demand

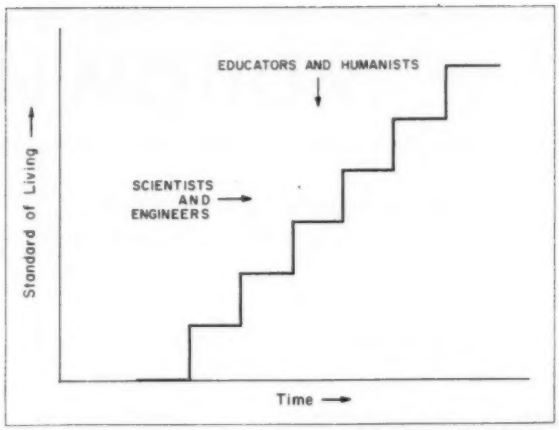
progress – in fact we seem to take it for granted as a law of nature – but there are influential people who seem to be doing their best in our education process to escape or circumvent science and technology, which alone can make progress possible.

Perhaps I have overstated my case. Let us hope so – but a review of some recent evidence may give us a perspective in which to view the problem. In a recent study of high school students reported from Purdue,[6] it was found that: 14 per cent of the students think there is something evil about scientists; 30 per cent believe that one cannot raise a normal family and become a scientist; 45 per cent think their school background is too poor to permit them to choose science as a career; 9 per cent believe that one cannot be a scientist and be honest; 25 per cent think scientists as a group are more than a little bit "odd"; 28 per cent do not believe scientists have time to enjoy life; 35 per cent believe that it is necessary to be a genius to become a good scientist; 27 per cent think that scientists are willing to sacrifice the welfare of others to further their own interests.

This is indeed a devastating comment – either on scientists, or on our educational process, or both. With this the attitude among students, can there be any mystery as to why there is currently a shortage of scientists and engineers? Since the world managed to survive for some centuries before the advent of scientists or engineers, the attitudes expressed would be quite understandable if the students were or proposed to become mystics and lead the contemplative life, which certainly has its advantages. But these were normal American boys and girls demanding and getting 100-horsepower cars for transportation, radios, television, movies, juke boxes, and all the other paraphernalia of our modern civilization. How could they have grown to high school or college age without learning the simple facts of cause and effect with respect to the technological civilization in which they are clearly planning to live?

In this respect our school system is quite inadequate, in my opinion. The shortage of scientists and engineers is bad enough, but with some effort these immediate shortages can be corrected since the total numbers needed are not really large in proportion to the population. What is more serious (and more dangerous in the long run) is that the mass of our population, who, in a society dedicated to the greatest good for the greatest number, must in the end control it, remains in ignorance of the foundations on which that society is based.

The contrast between the studied complacency of the educators and the concern of scientists and engineers with regard to this situation can perhaps be emphasized or dramatized by Koester's device of using a staircase to show the effects of different points of view bearing on the same problem. In Fig. 1 the humanist or so-called "progressive" educator looking from above sees a series of plateaus or tableaus (since they are flat to him) and notes with amazement and delight that each successive tableau shows a successively higher standard of living. With only a limited imagination he can make the slight extrapolation to the point where no one has to work. Being foresighted, he places great emphasis on training



M.I.T. Illustration Service

Fig. 1. The standard of living rises with the passage of time, but this effect is seen differently by two important groups of persons.

for leisure. Being also sufficiently observant to note an increase of population with time, and being aware of the frictions and struggles brought about by individual differences, great emphasis is also placed on standardization. For the convenience of all concerned, why shouldn't the "lowest common denominator" solution be picked? From his point of view it makes sense.

Now look at the same staircase from the point of view of the scientist. He sees each plateau merely as a hesitation point between struggles to attain a higher level. To him progress represents work, and he is convinced that further progress cannot be made without struggle. To him there is nothing automatic or guaranteed in the comfortable and continuous progress which the humanist and progressive educator seem to take for granted.

A rough indication of the relative contributions of science and technology can be seen from Fig. 2, adapted from the book by Harrison Brown.[7] This shows the extent to which science and technology have dominated modern life. Art, literature, poetry,

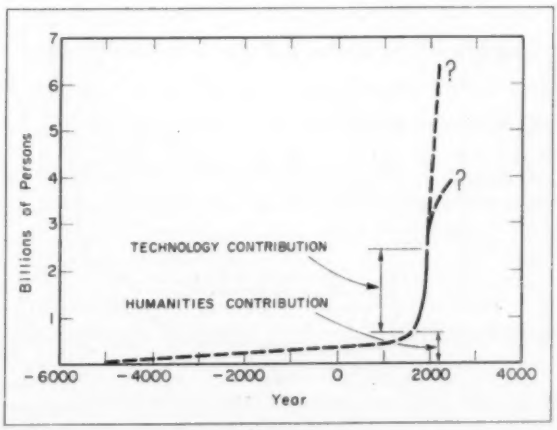


Fig. 2. The world's population has increased three times as much in the past three centuries as in all previously known recorded history.

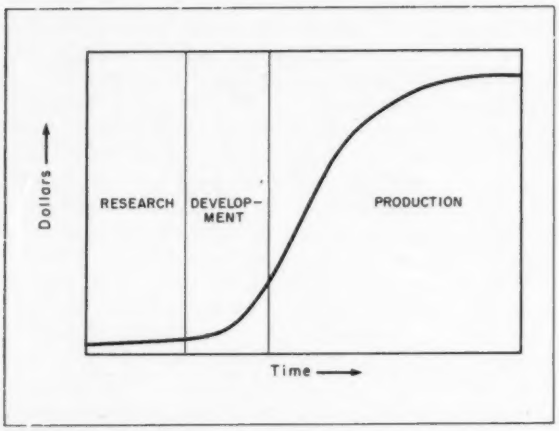


Fig. 3. Typical growth curve for total costs of new product. Research and development costs are low; production costs, relatively high.

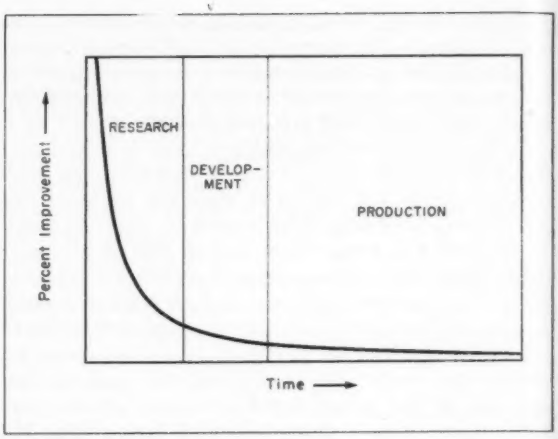


Fig. 4. Curve showing improvement of product plotted against time. Research makes large contribution; production, small contribution.

warfare, trade, government, law – all have been with us from prehistoric times. As H. G. Wells has pointed out, the first episodes in recorded history involve the quarrels of Sumerian priests. Apparently none of the accomplishments of these groups was sufficient to break the monotonous cyclical rise and fall of the same kind and level of civilization in merely different locations, such as in China, Egypt, Greece, and Rome. Taking simple survival as the lowest level of human happiness and integrating for all mankind, we find a total contribution for the humanities as given by an extrapolation to the present time, of the first part of the curve of Fig. 2. The rapid growth of the population curve after the Seventeenth Century is commonly attributed to the development of science and technology, so the relative contribution of these disciplines to humanity as a whole can be taken as roughly three to one over that of what used to be called the humanities. Considering the relative contribution of these two kinds of activities to the good of mankind, one wonders whether perhaps the names should not be interchanged!

Since our society has chosen for itself a kind of civilization which is so overwhelmingly dependent on advances in science and technology, it is only prudent to ask how we can expedite our progress in these fields. Here is where the shortage of scientists and engineers comes in. I will not attempt to review but merely cite some of the many excellent and realistic articles on this subject. Significant, in my opinion, are recent articles by Stratton, Rassweiler, Rickover, Bestor, and Beckman.[8]

These articles, by unquestioned authorities in their fields, point out inadequacies in our present educational system in so far as the production of technical personnel is concerned. I agree heartily, but I wish to make a deeper criticism. Even if an entirely sepa-

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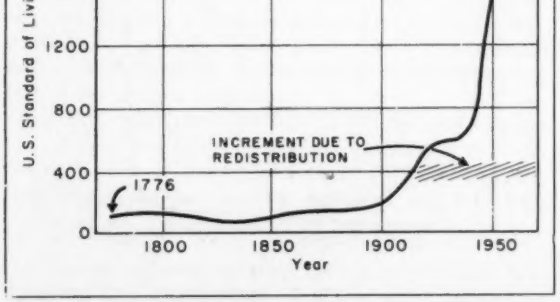


Fig. 5. Standard of living in the United States. Shaded area shows gain in standard of living due to leveling of incomes of all kinds.

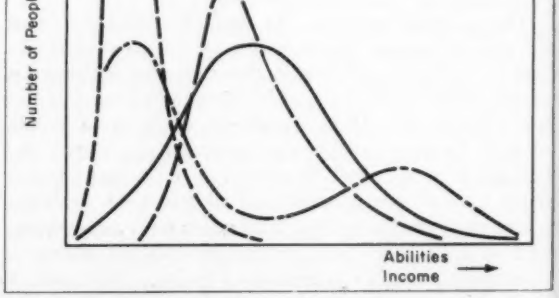


Fig. 6. Distribution of abilities of a population, together with distribution of income in two drastically different kinds of societies.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Under today's competitive conditions, a manufacturer can't afford to take anything for granted. He continually seeks to improve even the so-called "perfect" product and to reduce production costs.

One such progressive manufacturer, in reviewing the materials and processes used in making their spherical roller bearing cages, sought the opinion of others. One of those "others" was Revere's Technical Advisory Service, which was called in to review the kind of brass that was being used in the cages and to study the problem first-hand. This meant consulting with the engineering department as well as observing the manner in which the bearing cages were being produced.

After a careful study recommendations were made. The result was the adoption of specification changes in the brass strip used which, in addition to improving the quality of their roller bearing cages, gave this manufacturer the following money-saving advantages: One bore pressing operation has been eliminated. Machining is more easily accomplished. Less machining is required. Tool life has been increased with some speeds increased up to 100% and feeds up to 30%. Rework due to burrs has been greatly reduced. One step less is required in the deburring operation while savings through reduced cycle time for remaining deburring operations are up to 40%. Chips are small now . . . there is no "angel hair" to clutter work area. Life of punch used in notching roller bearing cage has been doubled. Now a run may be completed without making tool adjustments due to sharpening tools. Machining speeds and feeds have been substantially increased over those in machining the former alloy. Die setters report that considerable work has been eliminated in setting up the tools used. All of which resulted in substantial savings in time and money.

This is still another eye-opening example of Revere supplying the metal that will do the best job and with the greatest economy . . . be it brass, copper or aluminum or any one of their alloys. It is also another example of the many advantages of working closely with *your* supplier, whether it be through Purchasing, Production, Engineering or Design Departments, separately or collectively. It is one sound way to go about lowering production costs, improving manufacturing techniques and bettering *your* product.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices: 230 Park Avenue, New York 17, N. Y.

SCIENCE, TECHNOLOGY, and SOCIETY

(*Continued from page 114*)

rate educational channel were provided which more than supplied our foreseeable needs for engineers, I contend that the education of the rest of the citizenry should include a basic understanding and appreciation of our technological society, both its strengths and its limitations. Above all, at some point in the education process it should perhaps be brought to the attention of the students (very delicately, to be sure, to avoid psychological trauma) that progress cannot be made without struggle, nor freedom enjoyed without personal responsibility.

It has long been my contention that those who have *done* should teach, and accordingly that those who have taken an active part in creating our technological society should be best able to interpret it for others. Unfortunately, the very shortage of technical talent exerts great pressures on individuals skilled in these fields to concentrate on technical problems. Scientists and engineers are notoriously inarticulate, so a suitable education should include a heavy concentration on the arts of communication. This might be acquired in our elementary or secondary schools, but in our present predominantly superkindergarten system of education it is postponed until college. Here it is in conflict with the needs of ever more highly specialized professional training. The engineer remains inarticulate and the general public uninformed; thus the impedance mismatch is continuously increased, not decreased, and must eventually result in instability.

Glenn Frank has stated this problem with fine understanding. He says:

> The practical value of every social invention or material discovery depends upon its being adequately interpreted to the masses. The future of scientific progress depends as much on the interpretative mind as it does upon the creative mind. . . . The interpreter stands between the layman, whose knowledge of all things is indefinite – and the scientist whose knowledge of one thing is authoritative. . . . The scientist advances knowledge. . . . The interpreter advances progress. . . . History affords abundant evidence that civilization has advanced in direct ratio to the efficiency with which the thought of the thinkers has been translated into the language of the masses.[5]

In contacts with students and even with reasonably informed grown-ups, I have found that such simple and basic things as the relation between research and engineering, between technology and the standard of living, or between progress and incentive, not only are not understood but that the discussion of these concepts is itself a fascinating *new* experience. An Operations Research approach to some of these problems might prove quite rewarding.

Here are some simple examples which I have found to stimulate considerable interest in discussion groups.

First, in regard to the relation between science and engineering or research and engineering, let us look at Fig. 3. This curve shows the usual growth curve for costs of a project of some kind. Note that the costs during the research or information-gathering phase are small. It is only at the beginning of the development or invention phase that there is anything tangible to consider and that costs begin to mount. It is here that the businessman first begins to take an interest, and it is this phase of the effort which he considers important.

To a research man, however, the picture looks entirely different. The business of the researcher is to get really new information, to discover a relationship which previously had never been known, to do something – not better or cheaper than somebody else – but to do something for the first time in the history of the human race. Research discoveries are rarely spectacular but may nevertheless be highly significant. Thus, to bring out what is important in research we might plot, not dollars expended, but the ratio of the information available in a certain field before an experiment and after an experiment. If something truly new has been discovered, this ratio becomes infinite and a replot of our previous Figure, in terms of this information ratio, becomes as shown in Fig. 4. This curve emphasizes basic research, the acquisition of knowledge for its own sake.

Scientists Do Not Create Technology

The scientist's work as a scientist is completed when a new item of information is established and recorded. It is no concern of the scientist, as a scientist, whether the information is useful or not. It is for this reason that we can say with conviction that it is not scientists who create technology. It is society itself which chooses to create a technology based on the information which the scientist has uncovered. This problem of application is the function of the engineer. At the beginning of the scientific era, science and engineering were widely separated in time. With the development of our current technological civilization, applications have followed more and more closely on the heels of discovery, with the result that in many fields the search for new information and understanding is carried out simultaneously with the application – that is, the effort to solve some practical problem. Though activities may overlap, the distinction in function remains. The same man who makes a discovery may choose, or be persuaded, to attempt to apply it to a practical problem. In this case he ceases to be a scientist and works essentially as an engineer, and is motivated not internally as a scientist but externally by society. I dwell on this point to counter the argument often advanced that it is the scientist who has created the complexities of our modern industrial civilization. I maintain it is not. It is society itself, and particularly the nontechnical part of society, which creates the demands which are the motive force behind our technology.

Let us turn to another basic question, the relations between standards of living, education, and technology. Much of the energy in our educational system these days is focused on new theories of teaching which will avoid grading and thus any semblance of conflict and competition. This is no

(*Continued on page 118*)

SEVEN AGES OF THE TELEPHONE

ALL THE WORLD'S A STAGE, *and all the men and women merely players. . . . And one man in his time plays many parts, his acts being seven ages. At first the infant . . .* SHAKESPEARE

All through the years, from babyhood on, the telephone is an important, indispensable part of almost everything we do. And as the hands that grasp the telephone grow in size and usefulness, so grows also the usefulness of the telephone.

BABY DAYS At first the telephone is just something that rings. But soon the lusty newcomer is saying "hello, Daddy" all by himself and listening in wide-eyed wonder to the magic of Daddy's voice.

GROWING UP It isn't long before the telephone becomes more than a magical fascination. It begins to be something for doing things. A particular pal to call. And a very necessary part of growing up.

DYNAMIC TEENS Life is now a whirl of activity. So many things to do. Girl talks to girl. And boy talks to girl. And there are two happy hearts when she says, "I'd love to go."

JUST MARRIED Two starry-eyed young people starting a new life together. The telephone, which is so much a part of courtship, is also a big help in all the marriage plans and in getting settled.

EARNING A LIVING The years go by and always there is the responsibility of earning a living. Here again the telephone is a speedy, willing, ever-present helper. It is a part of the daily work and the progress of almost everyone.

RAISING A FAMILY Now the telephone becomes more useful than ever. For how could Mother ever run her household and raise a family without it! Friends, relatives, stores, doctors, conveniences—all are so easy to reach by telephone.

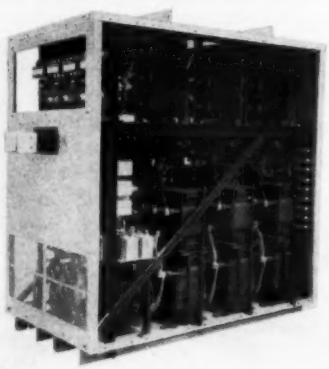
IT'S GRANDMA NOW And now she's holding a grandchild on her lap. The telephone that has served her so faithfully now starts a new era of service. The cycle of life and the seven ages of the telephone begin all over again.

Working together to bring people together . . . **BELL TELEPHONE SYSTEM**

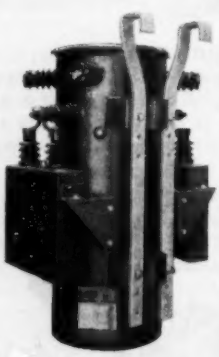
HEVI DUTY

IN STEP
with tomorrow's
stepped-up
DEMANDS

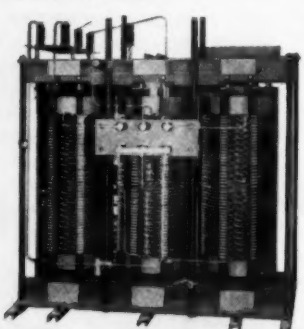
DRY TYPE TRANSFORMERS,
CONSTANT CURRENT REGULATORS
AND SATURABLE REACTORS



CONSTANT CURRENT REGULATOR used in an industrial electrochemical process.



CONSTANT CURRENT REGULATOR for street, subway and airport lighting.



DRY TYPE TRANSFORMER, 300 KVA, for unit substation. Other transformers are available from 5VA to 2000 KVA as well as Saturable Reactors from 25VA to 500 KVA.

HEVI-DUTY ELECTRIC COMPANY

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SCIENCE, TECHNOLOGY, and SOCIETY

(*Continued from page 116*)

doubt desirable sociologically, but apparently so is a rising standard of living. This presents a painful choice. In technology if incentive is removed, so is struggle – and if struggle is stopped, so is progress. This leveling process could, of course, be carried out at any point in the history of a civilization, so it is of interest to see what would have happened had it been carried out at some previous time in our own history. The results are shown in Fig. 5.[10] Who made the greatest real contribution to the goal of the humanist, the engineers or the self-appointed Robin Hoods of 1909, those people who thought all our social problems could be solved by a redistribution of the wealth at that time?

Finally, let us consider a little further the relationship between incentive and progress. Let us assume, following the late H. C. Dickinson of the Bureau of Standards, that the actual innate abilities of a population are given by a probability distribution such as the solid curve in Fig. 6. As a base for comparison, let us now imagine a perfectly "efficient and just" social system which extracted from each individual a contribution proportional to his ability and rewarded him in accord with his contribution. The dollar income curve would then coincide precisely with the ability curve. But there are many other criteria society can choose to specify the income curve. In the United States we originally chose to give "rate of progress" great importance in our specification, and emphasized incentive, but we balanced this with benefits for the underprivileged, which gave us a distribution curve, according to Dickinson, something like the dash-line curve marked "U. S. Income." The Marxian criterion, on the other hand, was "From each according to his ability to each according to his need." The experiment was tried, as we all know, and according to reports resulted in a peaking of the curve just at, or barely above, the subsistence level, as in the highly peaked curve at the left marked "Early Marxian." Clearly this represented a sharing of poverty, as Herbert Hoover has so aptly phrased it. This failure of a social theory forced the Soviet to adopt the "New Economic Plan," with a return to emphasis on incentive to bring out the potential contributions of the able. The new curve, of course, has a new specification which I am sure is intended to maximize progress. To attain such progress, however, the Communists have distorted their reward curve to some such as the double-hump curve, with the mass of the population at subsistence level and a pampered elite at the top. The stresses and strains thus introduced into their society are only now becoming evident.

Conclusion

In summary, there is a continuing divergence in point of view between the sciences and the humanities. With the sciences, through the mechanism of technology, being called upon to make an ever-increasing contribution to a society as specified by the humanists, there is serious cause for concern in the

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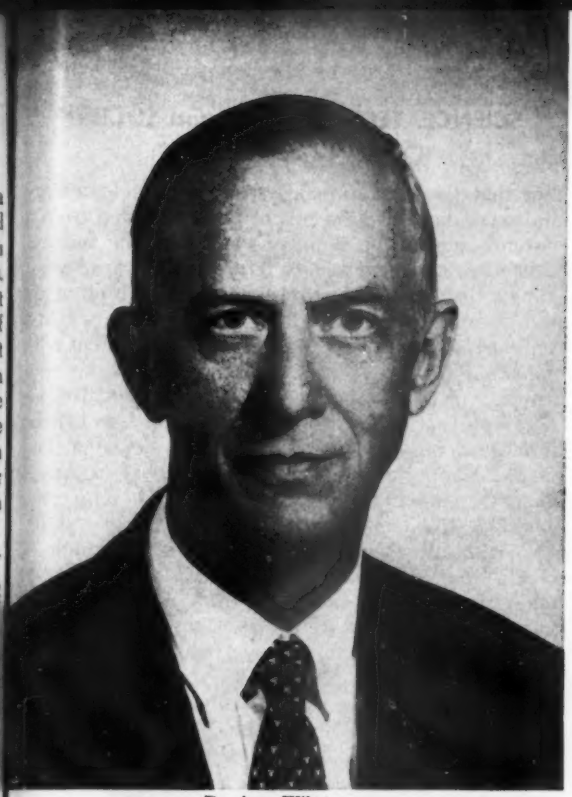
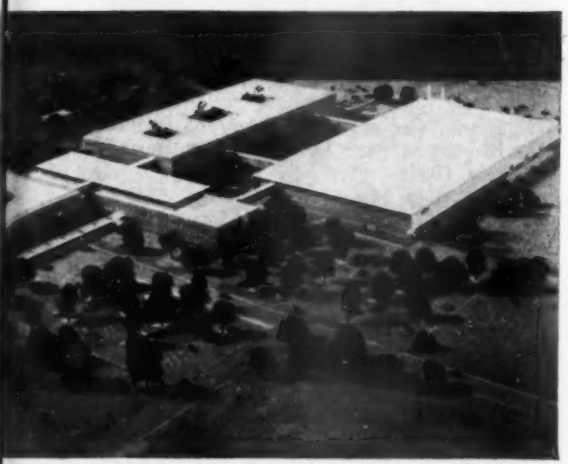


Dr. Arne Wikstrom



Pictured above is our new Research and Development Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultramodern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

Avco's new research division now offers unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers in such fields as:

Science:
Aerodynamics · Electronics · Mathematics · Metallurgy
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Heat Transfer · Mechanical · Reliability · Flight Test

Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

A SCIENTIST-ENGINEER SPEAKS ABOUT AVCO

MORE AND MORE it is being appreciated that no sharp borderline between science and engineering should exist. These two fields must strongly overlap to bring into being the fullest creativity of both.

To span the gap between science and engineering is one of the *big* problems—it is one which no laboratory can ignore. In this no-man's-land there are engineers who are physicists and physicists who are engineers. Avco is encouraging a staff of such men, men who are highly trained in the sciences but who realize that the ultimate goal is to apply this knowledge in ways that will enable mankind to live better in a better world of tomorrow.

Industrial research must rest on the foundation provided by the creative basic scientist. Yet its end product—new commercial items, new defense systems and new techniques—comes into being only through the insight and skill of the creative engineer.

Avco's newest division has a climate of creativity, coupled with long-range corporate goals. In this atmosphere creative and far-sighted professional men, whether scientist, engineer or any one of the infinite number of combinations thereof, will find rewarding work at the Research and Advanced Development Division of Avco.

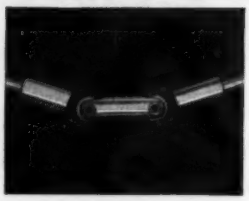
A. Wikstrom

Dr. Arne Wikstrom
Special Technical Assistant to the President

Avco
Research & Advanced Development

How Curtis helped a design engineer "BEAT THE HEAT"

This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

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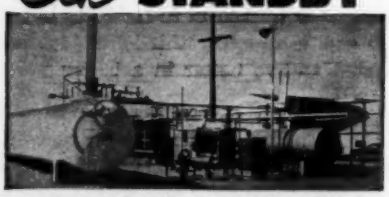

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SCIENCE, TECHNOLOGY, and SOCIETY

(*Concluded from page 118*)

fact that the educational system at the elementary and secondary levels seems to be out of step from a systems-engineering point of view with the foreseeable needs of such a society. The desire for "progress" cannot be reconciled with the lack of attention to, and an incentive for, students of exceptional ability. Similiarly the desire for "progress" is inconsistent with the trend toward effortless education, and the substitution of pastimes for disciplines. Finally, the assumption that a larger and larger population can be supported on and by the work of a smaller and smaller fraction of highly trained creative specialists leads to a social structure like that of an inverted pyramid. Even more acute than the current shortage of scientists and engineers is the shortage of people who both can and will carry responsibility.

With increasing complexity and specialization in the technical fields, the gap between the sciences and the humanities becomes an ever-widening one. This adverse tendency could be reduced by insuring that students of science were given a better grounding in the humanities, while students in the humanities were given a better background in science. This, however, would require more rather than less disciplined study in both fields, and runs counter to the current educational trends.

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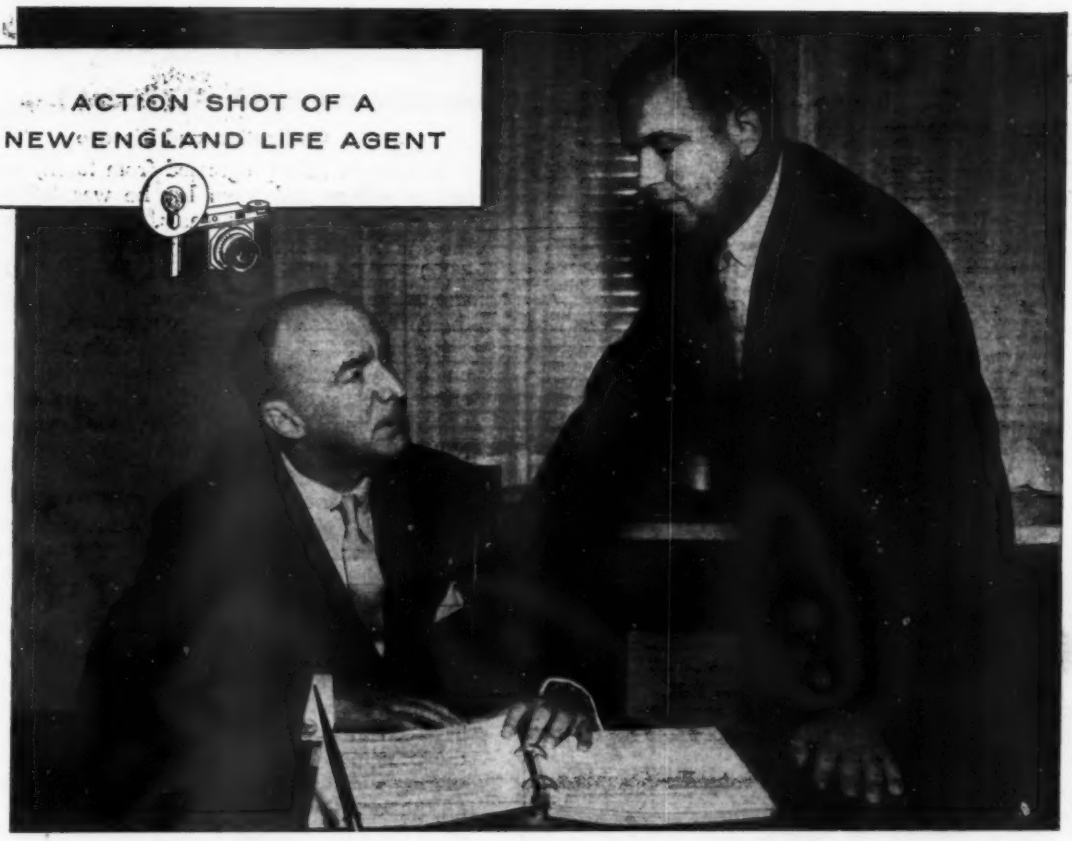

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ANTIQUITY OF DISEASE

(*Concluded from page 110*)

Civilization and Disease

As soon as man progressed from family and clan life to village and town life he was undoubtedly plagued with crowd diseases, or epidemics. Since the annals of recorded history go back no more than 6,000 years and are pretty dim beyond 5,000 years ago, we do not know much about what happened in the early stages of so-called civilization.

Between 3,000 and 4,000 years before Christ, great civilizations were, however, flourishing in the fertile crescent between the Tigris and Euphrates Rivers in Mesopotamia and also along the lush valley of the Nile in Egypt. Other notable civilizations existed then or later in Chaldea and Phoenicia and across the sea in Crete.

Perhaps the first known historic allusion to a pestilence was written on a clay tablet in Asia Minor about 3,200 years ago. On or about 1334 B.C. a king of the Hittites named Arnuwandas III died of a plague after a reign of only one year. His successor, Mursilis II, thereupon wrote or had written upon clay tablets an impassioned literary document entitled, "Prayers in Time of Plague," in which the harassed monarch offered lavish atonement gifts to the principal deity, the Hattian Weather God, imploring him to stay the pestilence which was upon all the land. We do not, of course, have any inkling as to the nature of this great epidemic. The Hittites, incidentally, also left behind a number of interesting medical treatises, as did the Sumerians and the ancient Egyptians. From them we can glean the facts that many diseases were rife in these venerable civilizations. Examinations of thousands of ancient Egyptian mummies likewise have shown the existence of numerous maladies, some of an infectious and contagious nature. But, as Kipling says, that is another story.

From 300,000 years ago to 3,000 years ago to the present time, man has been afflicted with individual and epidemic and pandemic diseases, some of which have come dangerously close to the extermination of the human race. In the short space of a little less than a century, a fraction of a moment in geologic time, he has learned how to conquer most of the maladies with which he is and has been afflicted. This is a noteworthy achievement.

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WILLIAM BARTON ROGERS

(*Continued from page 108*)

tical findings. He was constantly going deeper to discover new principles and concepts. We see this combination of pure and applied science in his work on the Appalachian mountain chain to which I have already referred.

This symbiotic relationship between basic science and applied science found expression in his concept of technological education, and only today are American schools of engineering beginning to achieve first-rate education in such basic subjects as science, mathematics, and the humanities.

Unfortunately our national system of engineering education failed to follow Rogers' lead, with the result that it has been too narrow, that it has tended to train technicians rather than professional engineers. Today we are trying to catch up with Rogers. Our nation now asks of its engineers that they be more than technicians and narrow specialists, that they henceforth have a deeper grasp of the scientific principles and concepts fundamental to their understanding of nature and a broader foundation of liberal education embracing an understanding of man. It asks for more engineers who can, while achieving exceptional mastery of their specialty, avoid the easy, narrow rut of "excessive expertism" and go on to demonstrate *as engineers*, leadership in human affairs — the capacity to use and shape technology as a powerful instrument for enhancing the quality of our society and for contributing to the solution of the great human problems of our time.

As I have emphasized, Rogers believed that a truly professional education in science and technology required what he called a "large general cultivation." He wanted the humanities taught along with engineering and science. He anticipated the need of a new kind of institution, humanistic in purpose, with its center of gravity in the sciences instead of the classical studies, but with the humanities and social sciences fully represented and enthusiastically supported as full partners.

It was Rogers' hope that the polytechnic institute he envisaged would achieve breadth by "leading the thoughts of the practical student to those wider and

(*Continued on page 126*)

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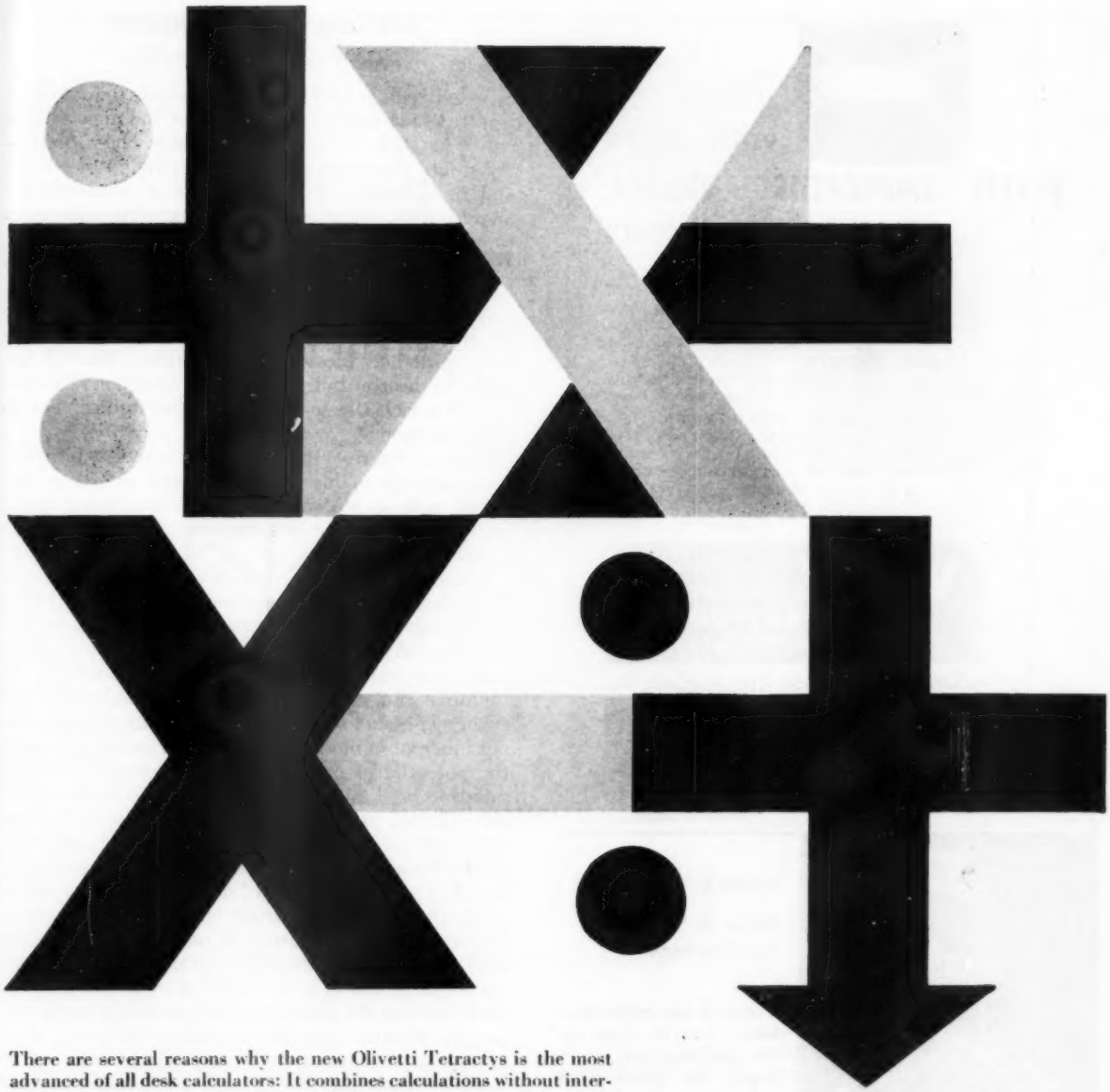

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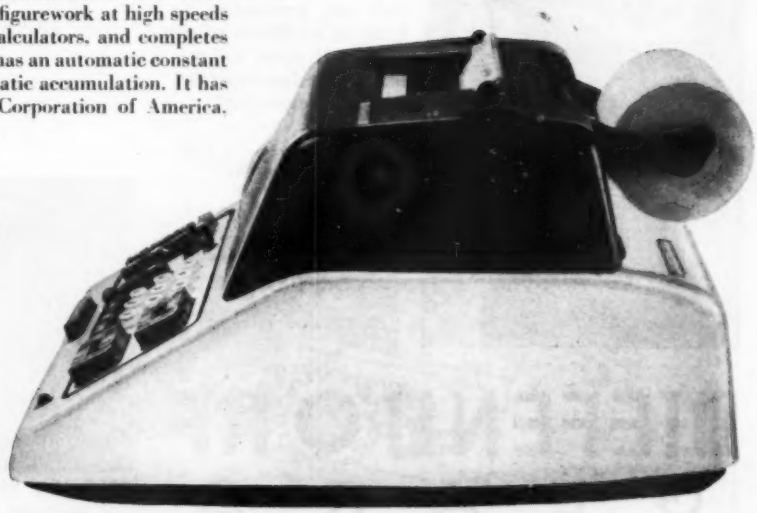

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WILLIAM BARTON ROGERS

(*Continued from page 124*)

elevated regions of reflection to which the study of Nature's laws never fails to conduct the mind." "It is easy," he said, "to extend the golden chain of relations until they may embrace every realm of Nature and of thought." This concept of a university for modern man, polarized about science, but concerned broadly with the welfare of society and of the dignity of man has come to be the aim of the institution Rogers founded.

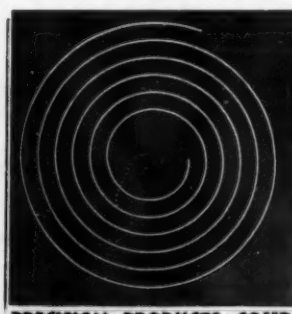
As another commentator has observed, "Rogers never broke with the cultural climate in which his own spirit had blossomed and fruited. He did not come to destroy but to fulfill the tradition – to add to and enrich the so-called 'cultural studies,' not to displace them."*

Rogers' interest in secondary school education, demonstrated in his Baltimore days, strikes a prophetic note as we see the great effort being made today to achieve better science teaching in our high schools.

There are several current efforts enlisting some of the ablest scientists in our country to design better high school courses, supplemented by new texts and new teaching aids. These hold the promise of deepening the teaching of secondary school science by building into it some of the intellectual rigor and excitement, some of the beauty and humanistic values inherent in modern science, thus making it match the potential of our intellectually competent young minds as well as the unfolding promise of science itself. If real progress could be made toward these ends, the new concepts, methods, and materials might be a pace-setting movement to increase the excellence and challenge of other parts of the school curriculum. One can hardly imagine an effort more important or more worthy of really bold and large-scale support than this effort to design special high school programs at a new level of excellence. In this direction lies the opportunity of providing our young people, whether they become scientists or not, some of the intellectual wealth of science, some of its unique vision for feeling and interpreting Nature, some of the understanding which our citizens should

(*Continued on page 128*)

*Treadwell Cleveland, "Technology Revisited," *The Technology Review*, 38-269 (April, 1936).



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WILLIAM BARTON ROGERS

(*Continued from page 126*)

have to deal more effectively with the great issues of our time arising out of science.

At the college level, we still have far to go to make science a meaningful part of our liberal arts education — which Rogers felt it ought to be, just as he believed that "a large general cultivation" should be the aim of scientific education.

If we are to survive as a nation, science most certainly will play an increasingly large part in our national life. A man cannot be really educated in a relevant way for the needs of our modern life unless he has an understanding of the values of science.

We are gravely concerned today about the shortage of scientists and engineers, as we should be. We see a hostile society making an unprecedented and successful effort to mobilize science and technology for the uses of an oligarchy that openly proclaims its intention of "beating us out," both industrially and militarily.

However much we may perceive variations of strength in the fine structure of Soviet science, we must agree that they have achieved an over-all capability that can profoundly affect the balance of military and industrial power. We in the United States cannot lag or flag one minute in our scientific, technological, or educational effort if we are to avoid dropping back into a position of disadvantage. We need not only to strengthen our education in science and engineering. We need to give greater emphasis to basic research in relation to applied or development research.

There are certain things we should not do. We should not let ourselves be bemused by numbers. We should not engage in an academic numbers race with the Soviets. We should not copy their narrow, overspecialized education. We should not throw quality out the window in order to handle numbers; our shortage is one of quality as well as numbers, versatility and breadth as well as specialized competence.

We do need to move steadily forward in the great tradition of William Small and Jefferson and Rogers, whose mind was fired and shaped by their ideas.

(*Concluded on page 130*)

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WILLIAM BARTON ROGERS

(Concluded from page 128)

If we can continue to develop and enhance this broader view, this indigenous American view of science, we need not be bearish about American science and scientific education. We must dock any weaknesses which appear, fill in the gaps, draw forth their latencies of creativity and excellence, afford them the means to meet the rising requirements imposed by our increasingly complex industrial society and our immense responsibilities to deter war and strengthen the free world.

Especially must we cultivate the latent strength of our total education and give it the new capabilities to meet advancing requirements for skill and talent, to realize more fully than we do now the innate potential of our human resources. This is the time for another great surge, another enhancement of faith and commitments in education — in our kind of education, our kind of intellectual freedom, our kind of social mobility and opportunity through education. Our purpose should be, not the ignoble one of beating somebody out, but the fulfillment of wishes deep in the hearts of men — a greater nation, a stable peace, a better world.

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and the prophet replied:
*"It is well to give when asked, but it is better to give unasked, through understanding."**

Gifts by Will

TO THE

Massachusetts Institute of Technology

The tale is told of Almustafa, the prophet, who, having awaited for many years the ship that would return him to the place from whence he came, was making the final descent to the shore when the folk of Orphalese crowded about him. They besought him before departing to "disclose us to ourselves, and tell us all that has been shown you of that which is between birth and death."

With words of wisdom, an answer appropriate was given to the woman holding a baby, to the ploughman, to the merchant. Begged one, "Speak to us of GIVING," and the prophet replied:

> "It is well to give when asked, but it is better to give unasked, through understanding;
> And to the open-handed the search for one who shall receive is joy greater than giving. All you have shall some day be given;
> Therefore give now, that the season of giving may be yours and not your inheritors'."

Through the years the prophet's words have held true, for even today he who "through understanding" includes the MASSACHUSETTS INSTITUTE OF TECHNOLOGY as a beneficiary in his will can experience thereby a two-fold satisfaction. The successful culmination of his search for a worthy recipient and the anticipated results his generosity will assist in accomplishing. These satisfactions give an added value to the span of man's days and project his usefulness to his fellowmen far into the future.

The Massachusetts Institute of Technology because of the high quality of the education given its students, its effective research work for aiding America in peace as well as in war, and the high character of its governing body and academic staff qualifies as an institution for serving our American ideals for the present and in the years to come.

But the search, the finding, and the anticipated accomplishments are not enough; for without the properly-worded record, man's plan for the future may go awry. Hence the prophet's importuning, "— give now," should be heeded. The giving need not be an immediate physical transaction, for written directions replace the spoken word when the speaker is no longer present, and a donor can frequently make by will a gift which is larger than he can make while living. Truly, *"it is well to give when asked, but it is better to give unasked, through understanding."*

A booklet "Gifts by Will," outlining different forms of bequests to M.I.T., is available to you or to your attorney by writing to:

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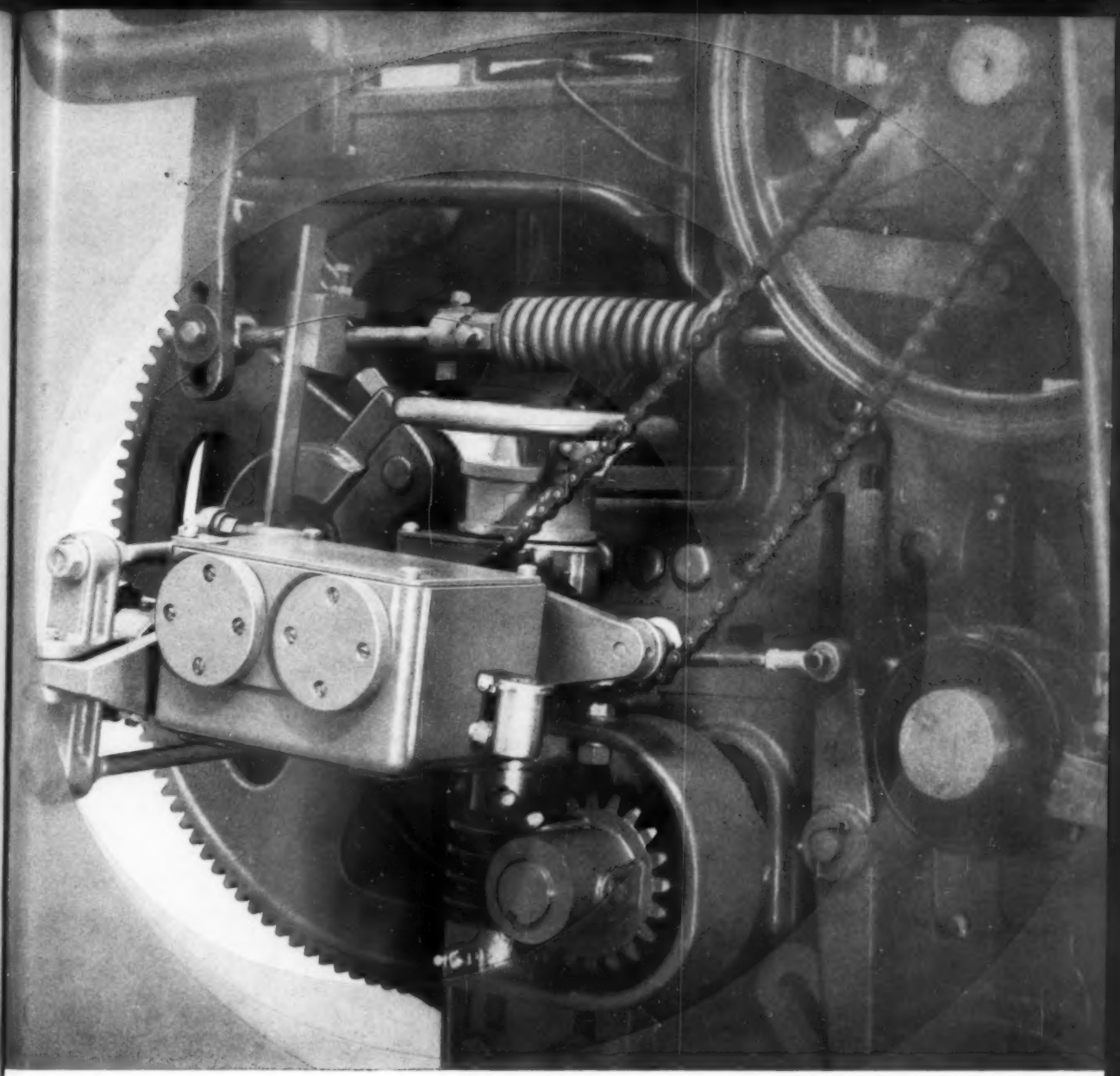
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

* "The Prophet" by Kahlil Gibran



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The Draper Tru-Tension Let-off controls yarn tension *automatically*, from full to empty beam. This is made possible by *a positive, continuous drive* and a compensating friction transmission.

The "Tru-Tension," a compact, precision built mechanism eliminates many cloth defects commonly attributed to the Let-off.

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The Tru-Tension Let-off is currently available for X-2, XD, and XP model looms. For additional information on this and other Draper products, consult your Draper representative.

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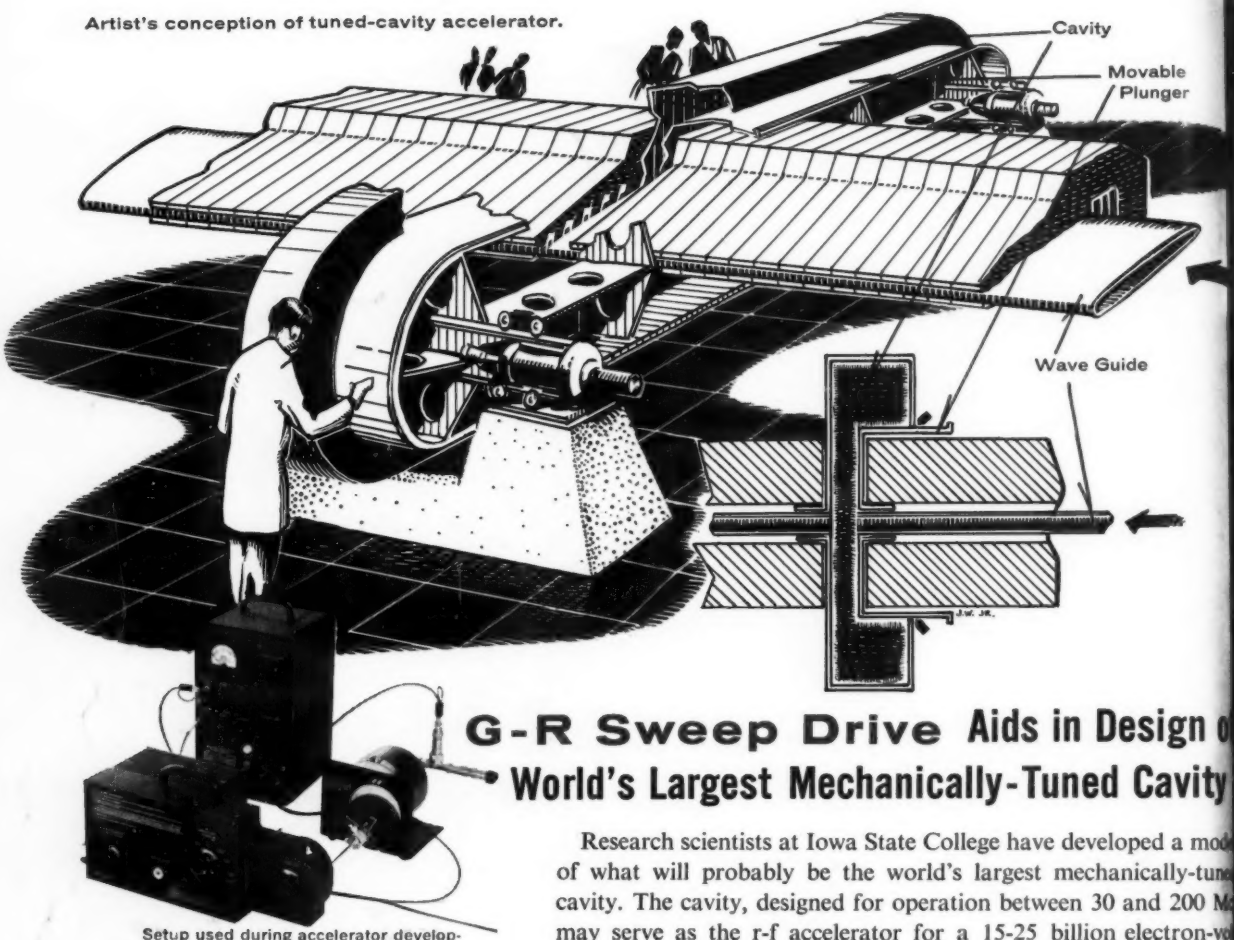
Artist's conception of tuned-cavity accelerator.



G-R Sweep Drive Aids in Design o World's Largest Mechanically-Tuned Cavity

Research scientists at Iowa State College have developed a mod of what will probably be the world's largest mechanically-tun cavity. The cavity, designed for operation between 30 and 200 M may serve as the r-f accelerator for a 15-25 billion electron-vo proton synchrotron. The cavity was designed under a project con ducted by the Midwest Universities Research Association, a grou of midwestern universities organized for the purpose of developin this new nuclear research device.

During development, the General Radio Sweep Drive proved in dispensable for determining the effects of design changes in cavit models. The Sweep Drive was coupled to a G-R Unit Oscillato which excited the cavity over a broad frequency range. The cavit output signal was rectified and applied to an oscilloscope with long-persistence screen. With this setup, cavity response could b panoramically displayed, making cavity resonances at various mode of oscillation clearly discernable and measurable.

Whether testing accelerators or amplifiers, the Sweep Drive cut testing time without reducing accuracy. It extends the usefulness o manually-operated equipment such as oscillators, signal generator receivers, and analyzers. It's a time-saver, labor-saver, and cos saver all rolled-in-one.

Setup used during accelerator development. Sweep Drive operates G-R Unit Oscillator while Type 1263-A Amplitude-Regulating Power Supply ($280) maintains constant oscillator output during sweeping. Constant output is obtained by comparing output signal with a reference voltage and applying a rapid correction voltage to oscillator plate supply.

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